AIRCRAFT INTERCEPTION COMPLEX МиГ-25-40Д (МиГ-25-40ДС)

COMBAT EMPLOYMENT MANUAL

The present Manual contains the brief characteristics of the МиГ-25ПД (МиГ-25ПДС) fighter, its armament control system, missiles, as well as the combat capabilities of the МиГ-25-40Д (МиГ-25-40ДС) aircraft interception complex, the basic methods of combat actions, actions of the pilot and the ground control post crew in destructing an air enemy.

The book contains 160 pages.

Chapter 1

BRIEF INFORMATION ON МиГ-25-40Д (МиГ-25-40ДС) AIRCRAFT INTERCEPTION COMPLEX

1.1. PURPOSE AND COMPONENTS

1. The МиГ-25-40Д (МиГ-25-40ДС) aircraft interception complex is designed for hitting the air targets of the strategic and tactical aviation and winged missiles in the daytime and at night under the VFR and IFR conditions (in clouds), as well as in the radiocontrast clouds and jamming conditions both in the free airspace and against the background of the earth.

2. The complex includes:

- the МиГ-25ПД (МиГ-25ПДС) fighter with the Р15БД-300 engines;
- the С-25 armament control system;
- the missile armament;
- the СРО-2 IFF aircraft transponder and the BRONZA aircraft interrogator;
- the 5У15К-11 airborne direction and target designation equipment;
- the POLJOT-1И navigation and landing system;
- the means for the objective check of the crew actions and proper function of the equipment;
- the ground control and direction system.

1.2. FLIGHT PERFORMANCE AND OPERATING LIMITATIONS OF FIGHTER

3. The combat capabilities of the МиГ-25ПД (МиГ-25ПДС) aircraft are determined first of all by the altitude and airspeed range of the level flight in destructing the air enemy (Fig. 1).

4. The maximum permissible indicated airspeeds are limited by the aircraft strength as well as by probability of initiation of the flutter and equal to:

- 1000 km/h, with the drop fuel tank attached;
- 1200 km/h, without the drop fuel tank, with the various variants of external stores at an altitude of up to 17,000 m.

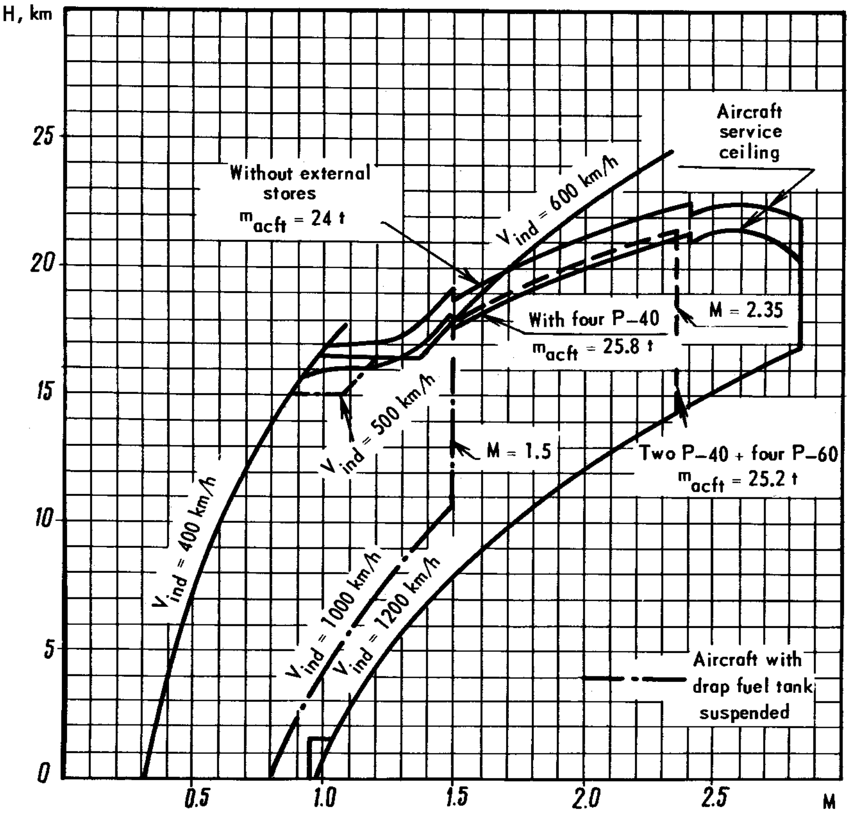


FIG. 1. RANGE OF OPERATING MACH NUMBERS AND FLIGHT ALTITUDES OF AIRCRAFT МиГ-25ПД (МиГ-25ПДС)

Note. After operation of the ВЛО$_{max}$ flight limitations warning computer (delivery of the LIMIT SPEED (СКОРОСТЬ ПРЕДЕЛЬНАЯ) voice information) the maximum airspeed may reach 1230 km/h before initiation of deceleration.

5. The maximum Mach number is restricted by the heat strength of the engines, heating of the homing heads of the P-60

missiles, directional stability of the aircraft carrying the drop fuel tank and amounts to:

- 2.83 for the aircraft without external stores or with the P-40 missiles at altitudes exceeding 17,000 m;
- 2.35 for the aircraft carrying the P-60 missiles at altitudes of not less than 14,500 m;
- 1.5 for the aircraft carrying the drop fuel tank at altitudes of not less than 11,000 m.

The flight endurance at the Mach numbers over 2.4 should not exceed 15 min (including 5 min, max., at the Mach numbers ranging from 2.65 to 2.83) and is limited by the heat strength of the engines. The time of flight at the Mach numbers of 2.4 and lower is not limited.

6. The minimum indicated airspeed of flight is 300 km/h.

7. The maneuvering indicated airspeed of the aircraft carrying no drop fuel tank amounts to:

- 400 km/h at altitudes from 0 to 16,500 m;
- 600 km/h at altitudes over 16,500 m.

When the aircraft carries the drop fuel tank, the maneuvering indicated airspeed amounts to:

- 400 km/h at altitudes from 0 to 15,000 m;
- 500 km/h at altitudes from 15,000 to 16,500 m;
- 600 km/h at altitudes over 16,500 m.

8. The maximum permissible positive vertical g-loads when flying with and without the missiles (Fig. 2) are limited by the aircraft strength and should not exceed the values indicated by the red movable sector of the g-load indicator.

The maximum permissible negative g-load when flying at the Mach numbers less than 1.5 is minus 1.5.

9. The service ceiling of the aircraft carrying four missiles P-40, with the engines running at the FULL REHEAT (ПОЛНЫЙ ФОРСАЖ) power setting and the fuel remainder being 3300 kg, amounts to 20,700 m at M = 2.5.

The minimum time of climb of the aircraft carrying four missiles P-40 to an altitude of 20,000 m at the true airspeed in gaining the above altitude being 2500 km/h (M = 2.35) equals 8.76 min. The acceleration and climb performance of the aircraft carrying two missiles P-40 and four missiles P-60 does not differ practically from that of the aircraft carrying four missiles P-40.

The time of climb is given with due allowance for the time of takeoff and acceleration up to the climb speed.

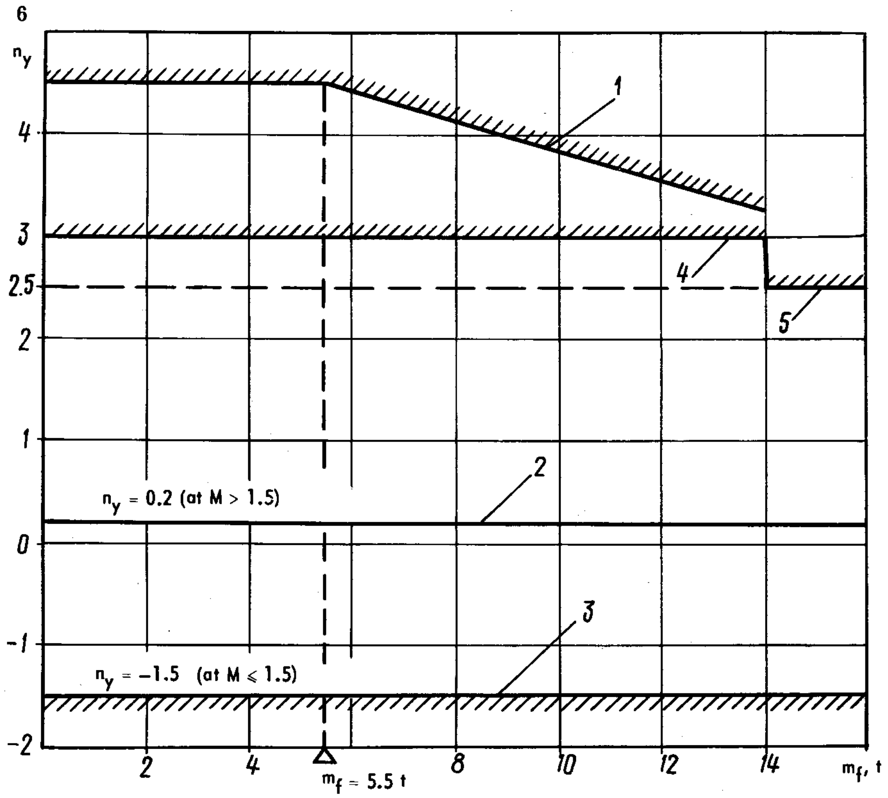


FIG. 2. MAXIMUM PERMISSIBLE G-LOADS

1 – maximum permissible g-load; 2 – minimum permissible g-load in flight at M>1.5; 3 – maximum permissible negative g-load in flight at M < 1.5; 4 – maximum permissible g-load ofter drop tank fuel runout (without jettison of drop fuel tank); 5 – maximum permissible g-load with drop fuel tank suspended

10. The aircraft takeoff mass is 40,770 kg, with the drop fuel tank and four missiles P-60 attached and the aircraft fuel tanks fully filled in with fuel. The takeoff mass of the aircraft carrying four missiles P-40, with the aircraft fuel tanks fully filled in with fuel, amounts to 37,000 kg.

The takeoff run of the aircraft carrying four missiles equals 1600 m.

The maximum permissible ground lift-off speed limited by the tyre strength is 400 km/h.

11. The design landing mass of the aircraft is limited by the airframe and landing gear members strength and amounts to 24,000 kg; in this case, the fuel remainder as read off the fuel quantity gauge should not exceed:

- 2550 kg for the aircraft carrying four missiles P-60;
- 2900 kg for the aircraft carrying no missiles.

12. The maximum landing mass of the aircraft is 26,000 kg; in this case, the fuel remainder as read off the fuel quantity gauge should not exceed:

- 3000 kg for the aircraft carrying four missiles P-40;
- 3600 kg for the aircraft carrying two missiles P-40 and four missiles P-60;
- 3950 kg for the aircraft carrying two missiles P-40;
- 4550 kg for the aircraft carrying four missiles P-60;
- 4900 kg for the aircraft carrying no missiles.

13. The maximum landing mass of the aircraft is 29,000 kg; in this case, the fuel remainder should not exceed:

- 6000 kg for the aircraft carrying four missiles P-40;
- 6600 kg for the aircraft carrying two missiles P-40 and four missiles P-60;
- 6950 kg for the aircraft carrying two missiles P-40;
- 7550 kg for the aircraft carrying four missiles P-60;
- 7900 kg for the aircraft carrying no missiles.

Notes: 1. When two or more missiles P-40 are suspended from the aircraft, the landing of the aircraft having the design landing mass, provided the remaining fuel amounts to 2200 kg, is not ensured.

2. When landing the aircraft with the drop fuel tank suspended, the fuel remainders specified in Items 11 and 12 should be reduced by 350 kg.

14. The maximum permissible indicated airspeed of flight, with the flaps and landing gear extended, is limited by their strength and should not exceed 700 km/h.

The maximum permissible ground touchdown speed is limited by the tyre strength and should not exceed 320 km/h.

The landing roll of the aircraft at a fuel remainder of 3000 kg, with no missiles suspended, provided that the drag chutes are automatically deployed and the wheel brakes are applied, is within 800 to 900 m.

In case of the drag chutes breakdown or failure to be deployed, the aircraft landing roll does not exceed 1250 m at the emergency braking and 1550 m at the normal braking.

The increase or decrease of the aircraft landing mass by 1000 kg results in variation of the landing speed by 5 km/h, respectively.

15. The maximum values of the service flight range depends on the aircraft airspeed and weight.

The maximum service flight range of the aircraft carrying four missiles P-40, when flying at a Mach number of 2.35 (H = 20,000 to 21,000 m), with the engines running at the FULL REHEAT (ПОЛНЫЙ ФОРСАЖ) power setting is 860 km.

The maximum service flight range of the aircraft carrying four missiles P-40, when flying at a Mach number of 0.85 (H = 8000 to 10,000 m), with the engines running at the MAXIMUM (МАКСИМАЛ) power setting, is 1290 km.

Owing to the fact that the actual conditions of flight, as a rule, differ from the accepted design ones, the data given in Item 15 may be used only for the approximate evaluation of the range. Prior to executing the particular flight in the actual conditions, it is necessary to perform the engineering-and-navigational calculations of the flight.

Perform the maximum-range flight at the supersonic speed, with and without the missiles, according to the following flight profile:

- take off at the full reheat power setting and switch off the afterburner when an indicated airspeed of 600 km/h is attained;

- climb to an altitude of 1000 m at the maximum power setting with acceleration of the aircraft to a true airspeed of 920 km/h for the aircraft carrying four missiles or to a true airspeed of 960 km/h for the aircraft carrying no missiles and then proceed climbing at a constant true airspeed of 920 or 960 km/h until a vertical speed of 3 to 5 m/s is gained;

- select the full reheat power setting and accelerate the aircraft in the straight-and-level flight to an indicated airspeed of 1150 km/h;

- climb at a constant indicated airspeed of 1150 km/h until a Mach number of 2.35 is obtained and then proceed climbing at a constant Mach number of 2.35;

- at an altitude of 17,500 to 18,000 m, select the partial reheat power setting (by throttling down the engines until the exhaust gas temperature drops by 20 to 30°C relative to the gas temperature at the full reheat power setting) for 2 or 3 s; on expiration of 1 min from the moment of throttling down the engines, change over the engines to the full reheat power setting for 3 to 5 s;

- accomplish the cruising climb flight at a constant Mach number of 2.35 at the full reheat power setting;

- switch off the afterburner, with the fuel remainder being at least 3300 kg, and decelerate the aircraft at the maximum power setting until a Mach number of 2.2 is obtained;

- on reaching a Mach number of 2.2, set the throttle lever to the IDLE (МАЛЫЙ ГАЗ) position and then proceed decelerating the aircraft until an indicated airspeed of 600 km/h is gained;

- descend at a constant indicated airspeed of 600 km/h at the idle power setting to the circling flight altitude.

Perform the maximum-range flight at the subsonic airspeed, with or without the missiles, according to the following flight profile:

- take off at the full reheat power setting and switch off the afterburner when an indicated airspeed of 600 km/h is obtained;

- climb to an altitude of 1000 m at the maximum power setting with acceleration of the aircraft to a true airspeed of 920 km/h for the aircraft carrying four missiles or to a true airspeed of 960 km/h for the aircraft carrying no missiles and then proceed climbing at a constant true airspeed of 920 or 960 km/h until a vertical speed of 3 to 5 m/s is gained;

- accomplish the cruising climb flight at a constant Mach number of 0.85, with the engines running at the maximum power setting;

- descend at a constant indicated airspeed of 600 km/h at the idle power to the circling flight altitude.

The basic parameters to be attained in climbing, level flight and descent to obtain the maximum flight range and endurance are represented by the indicated airspeed and Mach number of the flight.

When calculating the flight range and endurance, proceed from the usable capacity (amount) of fuel in the main system of the aircraft, equalling 17,180 lit or 14,520 kg (at $\rho_f = 0.845\ g/cm^3$).

When calculating the flight range and endurance at the assigned power setting or when estimating the fuel consumption in flight according to the preselected route, it is necessary to take into account:

- the fuel consumption for starting the engines - 150 kg;

- the fuel consumption for operation of the engines on the ground (the engines run-up by the pilot, taxiing) - 70 kg/min;
- the fuel consumption, time and distance covered during the takeoff and climb to the cruising flight altitude from the moment of the takeoff start - in compliance with the data given in Table 1;
- the fuel consumption per km and hour during the cruising climb flight at the Mach number stabilization mode - in compliance with the data given in Table 2;
- the fuel consumption per km and hour when flying the aircraft carrying the missiles at the low altitude in the maximum range mode - in compliance with the data presented in Table 3;
- the fuel consumption, time and distance covered during the aircraft descent from the cruising flight altitude to the estimated point of turn to the runway landing heading with the use of the POLJOT-1И system to an altitude of 600 km/h (or when the aircraft descends to the estimated point at an altitude of 2000 m for the landing approach from the estimated letdown line by reference to the automatic direction finder) - in compliance with the data given in Table 4;
- the fuel consumption during the landing approach from the estimated point of turn to the runway landing heading and up to the landing with the use of the POLJOT-1И system - 550 kg (the fuel consumption during the aircraft descent from the estimated point at an altitude of 2000 m and a range of 35 to 40 km up to the landing - 800 kg);
- the fuel consumption during the circling flight or go-around with the use of the POLJOT-1И system - 120 kg/min, with the landing gear retracted, and 220 kg/min, with the landing gear extended;
- the fuel consumption for climbing to an altitude of 2000 m, with the engines running at the maximum power setting, for the subsequent ejection (in case of failure of landing after go-around) - 1000 kg;
- the 7-per cent guaranteed fuel reserve taking into account the possible differences in the fuel consumption characteristics from the actual ones due to scattering of the engine parameters and aerodynamic characteristics of the aircraft - 1000 kg.

T a b l e 1

Flight altitude to which climb is performed, m	Aircraft with four missiles P-40			Aircraft without external stores		
	Fuel consumption, kg	Time, min. s	Distance, km	Fuel consumption, kg	Time, min. s	Distance, kg
1000	1100	1.40	0	1000	1.20	0
8000	3350	11.00	140	2800	7.00	85
9000	5500	14.10	210	3200	10.10	140
20,300	8300	17.50	335	7000	14.50	280
20,800	-	-		7400	15.40	310

Note. If the transition to the supersonic speed is performed at an altitude of 10,000 m, the fuel consumption, time and distance covered in climbing to the initial cruising climb flight altitude increase respectively as follows:

- for the aircraft carrying four missiles P-40 - approximately by 400 kg, 1 min 20 s and 20 km;
- for the aircraft without external stores - approximately by 150 kg, 30 s and 10 km.

Table 2

Altitude of cruising climb flight, m	Mach number of flight	Relative fuel consumption per km ($\bar{q}$, kg/km•t) on cruising climb flight leg	Fuel consumption per km (q) and per hour (Q)						Engine power setting
			At fuel remainder of 8000 kg read by flowmeter		At fuel remainder of 6000 kg read by flowmeter		At fuel remainder of 4000 kg read by flowmeter		
			q, kg/km	Q, kg/h	q, kg/km	Q, kg/h	q, kg/km	Q, kg/h	
Aircraft carrying four missiles P-40									
20,200 to 20,800	2.35	0.309	-	-	9.0	22,450	8.35	20,820	FULL REHEAT
8000 to 10,000	0.85	0.245	7.7	7190	7.15	6650	6.60	6200	MAXIMUM
Aircraft without external stores									
20,600 to 21,300	2.35	0.282	8.3	20,700	7.7	19,200	7.10	17,700	FULL REHEAT
9000 to 11,000	0.85	0.220	6.5	5970	6.0	5500	5.55	5140	MAXIMUM

Table 3

Flight altitude, m	Indicated airspeed, km/h	Fuel consumption per km, kg/km	Fuel consumption per hour, kg/h
500	700	14.5	10,700
1000	720	13.5	10,200

Note. Given in the table are the rates of fuel consumption per km and per hour for the aircraft carrying four missiles P-40 at the low altitudes in the maximum-range flying mode.

Table 4

Initial descent altitude, m	Fuel consumption, kg	Time, min.s	Distance, km
21,000	750	12.00	220
20,000	700	11.00	210
11,000	460	7.00	90
10,000	440	6.30	85
2000	80	1.10	10

Notes: 1. Fuel consumption, time and distance covered during descent to a circling altitude (600 m) are given with due allowance for aircraft deceleration from the cruise Mach number to an airspeed of 600 km/h.

2. Prior to descending, decelerate the aircraft at a constant altitude, with the engines running at the maximum power to M = 2.2 and then decelerate the aircraft, with the engines running at the idle power, to an airspeed of 600 km/h, after that glide at an airspeed of 600 km/h with the flaps up and engines running at the idle power.

One should bear in mind that increase of the ambient air temperature reduces the flight range and endurance owing to increase of the fuel consumption for climbing, and at the supersonic speed the flight range and endurance are additionally reduced owing to increase in the fuel consumption per km and per hour on the cruising climb flight legs. At M = 2.2 to 2.35 the temperature variation by $1^{\circ}C$ results in changing the fuel consumption per km approximately by 1%.

16. The basic engine operating modes and parameters checked on the ground and in flight are given in Table 5.

The permissible time of continuous operation of the engines running at the FULL REHEAT (ПОЛНЫЙ ФОРСАЖ) power, proceeding from the conditions of overheating of the afterburners, should not exceed 15 minutes. The repeated selection of the FULL REHEAT power setting may be performed not earlier than in one minute of the engine operation at the nonreheat power settings or at the partial reheat power setting.

The reliable selection of the REHEAT I (I ФОРСАЖ) power setting is ensured up to an altitude of 16,000 m at an indicated airspeed of at least 550 km/h, at the altitudes of 16,000 to 18,000 m at the airspeeds of at least 600 km/h, and selection of the REHEAT II (II ФОРСАЖ) power setting from the MAXIMUM II (II МАКСИМАЛ) power setting ($M > 1.5$) is ensured at the indicated airspeed of at least 650 km/h throughout the entire range of altitudes.

1.3. ARMAMENT CONTROL SYSTEM C-25

17. The C-25 armament control system is used for:

- guidance of the fighter on an air target at commands of the ground automatic control system;
- acquisition and identification of the air target;
- lock-on and tracking of the air target;
- delivery of the required commands and signals for ensuring the control of the fighter and employment of the P-40РД, P-40ТД, P-40T, P-60, P-60M guided missiles;
- display of the commands and signals on the screen of the integrated display system;
- illumination of the target when the latter is attacked by the missiles provided with the radar homing heads.

Table 5

Engine power setting	Thrust, kg	Specific fuel consumption, kg of fuel / kg of thrust·h	RPM, %	Exhaust gas temperature, °C, max.		Continuous operation time, s, max.		Engine inlet oil pressure, kgf/cm²	Jet nozzle diameter, mm
				on ground	in flight	on ground	in flight		
IDLE	370, max.	2200 lit/h	40^{+3}	650	650	600	Unlimited	At least 1.7	1170 (REHEAT II)
MAXIMUM I	7500	1.25	$94^{+0.5}_{-1.0}$	See Fig. 3	820	20	Unlimited	4±0.5	(945 (M))
MAXIMUM II			$99^{+1.0}_{-0.5}$	Not switched on	820	-	Unlimited	4±0.5	1110 (REHEAT I)
REHEAT I: - FULL	11,200	2.7	$94^{+0.5}_{-1.0}$	See Fig. 3	820	20	900	4±0.5	1110 (REHEAT I)
- MINIMUM	8350	2.2	$94^{+0.5}_{-1.0}$	See Fig. 3	820	20	Unlimited	4±0.5	
REHEAT II:									
- FULL		2.4	$99^{+1.0}_{-0.5}$	Not switched on	820	-	900	4±0.5	1170 (REHEAT II)
- MINIMUM		2.0	$99^{+1.0}_{-0.5}$	Not switched on	820	-	Unlimited	4±0.5	

<u>Notes:</u> 1. When the throttle lever is set to the MAXIMUM (МАКСИМАЛ) stop at a Mach number less than 1.5, the engine gains the MAXIMUM I (I МАКСИМАЛ) power setting.

2. The REHEAT I (I ФОРСАЖ) power setting is selected by setting the throttle lever to the FULL REHEAT (ПОЛНЫЙ ФОРСАЖ) stop at a Mach number less than 1.5. In this case, the annunciator displays the REHEAT signal, fuel injection into the afterburner initiates, the jet nozzle changes from the MAXIMUM to the REHEAT I position, the engine RPM are the same as at the MAXIMUM I power.

3. The REHEAT II power setting is selected automatically in flight when the aircraft is accelerated at the REHEAT I power and gains the Mach number of 1.5. This power setting is characterized by the change of the jet nozzle flaps from the REHEAT I to the REHEAT II position, development of a supersonic channel, engine RPM spinning from $94^{+0.5}_{-1.0}$ to $99^{+1.0}_{-0.5}$%, increase of fuel injection to the afterburner and by prominent increase of the engine thrust.

4. The engine thrust is changed both at the REHEAT I power setting and at the REHEAT II power setting by shifting the throttle lever from the FULL REHEAT stop to the MINIMUM REHEAT stop.

5. The MAXIMUM II power setting is a transient one. It is engaged by selection of the REHEAT II power and setting the throttle lever to the MAXIMUM stop. In this case, fuel is no more fed into the afterburner, the REHEAT annunciator becomes dead, the jet nozzle flaps change from the REHEAT II position to the REHEAT I position, the engine RPM remain constant, equal to $99^{+1.0}_{-0.5}$%. As the Mach number becomes lower than 1.5, the engine RPM automatically decrease from $99^{+1.0}_{-0.5}$ to $94^{+0.5}_{-1.0}$%, the jet nozzle flaps change over from the REHEAT I position to the MAXIMUM position and the engine changes over from the MAXIMUM II power setting to the MAXIMUM I power setting.

6. When the engine runs on the ground, the maximum exhaust gas temperature depends on the ambient air temperature (Fig. 3).

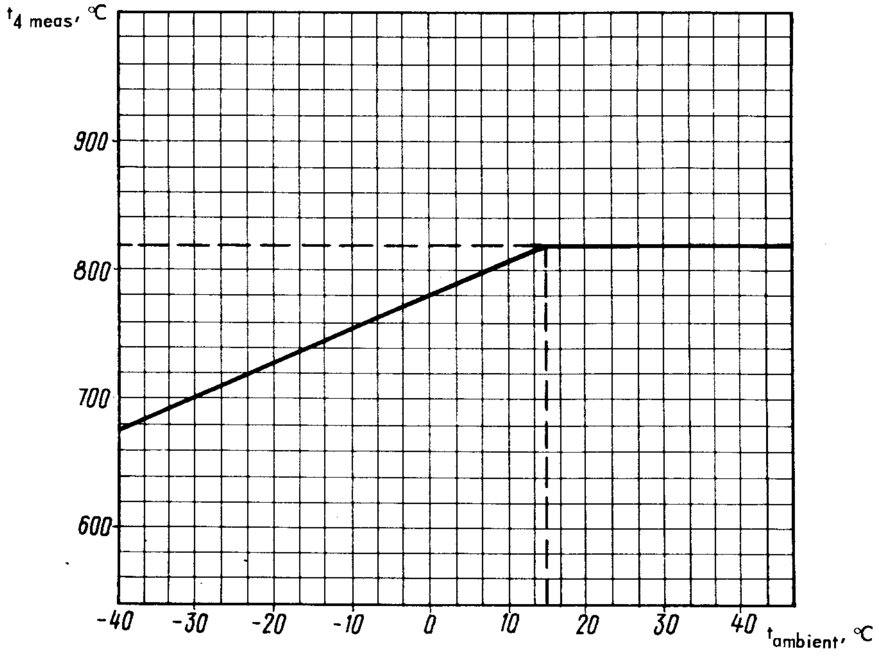


FIG. 3. LIMITATION OF TEMPERATURE t_4 AT "MAXIMUM I" AND "REHEAT I" POWER SETTINGS AS WELL AS OVERTEMPERATURES t_4 IN CHECKING ACCELERATION AT "IDLE" – "MAXIMUM I", "IDLE" – "REHEAT I" POWER SETTINGS (H = 0, M = 0)

1.3.1. Airborne Radar SAPFIR-25

18. The SAPFIR-25 airborne radar, according to its operating principle, is a pulse radar of the adder/differential type using the monopulse method of the target direction finding.

The SAPFIR-25 airborne radar has two basic operating modes: RDR (РЛ) and ATMOSPHERICS (МПХ) which may be set manually by the pilot.

The ATMOSPHERICS (МПХ) mode is used in attacking the air target flying in the cloud of the passive jamming or in the radiocontrast cloud.

The RDR (РЛ) mode includes four frequency operating modes: HMA (БСВ), HMA-ΔH (БСВ-ΔH), MLA (СМВ) and LA (МВ), which stand for the high, medium and low altitudes. The modes are selected automatically in tracking or manually in scanning depending on the target step-up (step-down) separation and the fighter flight altitude in compliance with the conditions given in Table 6.

Table 6

Mode selection conditions	Airborne radar operating modes			
	HMA	HMA-ΔH	MLA	LA
Fighter flight altitude, km	Above 1.5	Above 1.5	Less than 1.5	Less than 1.5
Antenna tilt angle relative to horizon, deg	More than +1.0	Less than +2.5	At least +1.5	Less than -1.0
Step-up (step-down) separation set by pilot, km	From +0.5 to 8	From +0.5 to -5	From 0 to +2	From -0.5 to -5

19. When the airborne radar operates in the HMA (БСВ) mode, it ensures execution of the forward-cone and rear-cone attacks in case of the step-up separation of the fighter from 1000 to 12,000 m with respect to the target. In this mode the airborne radar has the higher coverage, with the fighter flying at an altitude above 4500 m, owing to cutin of the parametric amplifier.

20. In the HMA-ΔH (БСВ-ΔH) mode, the airborne radar makes it possible to execute the forward-cone overhead air attack at the target flight altitude above 2000 m and the fighter flight altitude of not less than 4500 m, with the step-up separation of the fighter relative to the target being up to 5000 m, and the rear-cone overhead attack at the target flight altitude of not less than 1500 m and the fighter flight altitude of not less than 3000 m, with the step-up separation of the fighter relative to the target being up to 5000 m.

The optimum conditions of executing the attack in order to gain the maximum coverage of the airborne radar in the HMA-ΔH mode are ensured provided the following conditions are met:

$$H_{tgt} \leqslant H_{ftr} \leqslant 2H_{tgt}, \text{ when } \Delta H = H_{ftr} - H_{tgt} \leqslant 5000 \text{ m},$$

where: H_{tgt} is the target flight altitude;
H_{ftr} is the fighter flight altitude;
ΔH is the step-down separation of the target relative to the fighter.

21. In the MLA (СМВ) mode, the airborne radar ensures execution of the rear-cone underneath attack at the target flight altitude ranging from 500 to 1500 m, with the step-down separation of the fighter relative to the target being within 200 to 1000 m, and the forward-cone underneath attack at the target flight altitude ranging from 1500 to 3000 m and the fighter flight altitude ranging from 1000 to 1500 m.

22. In the LA (МВ) mode, the airborne radar ensures execution of the rear-cone attack of the pinpoint target (type МиГ-21) and the forward-cone attack of the large-size target (type Ту-16) in the VFR and IFR conditions at an aspect angle of 0/4 to 1/4 at the target flight altitude of 50 to 800 m and the fighter flight altitude of 500 to 1400 m, with the step-up separation of the fighter relative to the target being 500 to 800 m.

23. In the ATMOSPHERICS (МПХ) mode, the airborne radar ensures execution of the attack against the air target flying in the active jamming cloud or in the radiocontrast cloud when the MLA, HMA and HMA-ΔH modes cannot be used.

The ATMOSPHERICS mode allows the pilot to execute the forward-cone and rear-cone attacks against the air target flying at an altitude of not less than 2000 m, with the step-down separation of the fighter relative to the target or when the fighter and the target fly at the same altitude, and only the rear-cone attack when the target flying altitude is ranging from 1000 to 2000 m, with the step-down separation of the fighter relative to the target. Accomplish the overhead attack only against the targets flying at an altitude of not less than 3000 m and with the step-up separation of the fighter relative to the target being within 1000 to 2000 m.

In absence of the clouds or the passive jamming cloud within the radar coverage, the target will not be displayed on the indicator screen in this mode.

24. The SAPFIR-25 airborne radar ensures acquisition, lock-on and tracking of the low-speed air target (the helicopter, parachute target, balloon, etc.) in all specified operating modes, with the FHS - LST - RHS (ППС - МСЦ - ЗПС) selector switch set to the LST (МСЦ) position to cut off the speed selection circuit.

25. The SAPFIR-25 airborne radar has two antenna (scanning zone) control modes: manual and automatic.

The manual antenna control in azimuth is effected with the aid of the guidance control knob. The automatic control of the antenna in azimuth and elevation is ensured by the commands delivered from the ground automatic control system with the use of equipment 5У15К-11.

The angular characteristics of the scanning and autotracking zones depending on the airborne radar operating mode and the control method are given in Table 7.

26. With the airborne radar operating in the HMA mode, the dependence of the acquisition and lock-on ranges of the target versus its effective reflecting surface is shown in Fig. 4.

1.3.2. Heat Direction Finder ТП-26Ш1

27. The ТП-26Ш1 heat direction finder is used for detection and automatic tracking by the angular coordinates of the air targets by reference to their infrared radiation at any time of the day beyond the clouds.

Being a passive means of detection, the heat direction finder ensures:

- the covert search and lock-on of the target in the azimuth-elevation coordinates;
- delivery of the target designations and launch of the missiles furnished with the infrared homing head (radar homing

Table 7

Airborne radar operating mode	Control of antenna in scanning	Scanning zone, deg				Shift of scanning zone, deg		Tracking zone, deg	
		azimuth		elevation					
		FHS	RHS	FHS	RHS	in azimuth	in elevation	in azimuth	in elevation
HMA HMA-ΔH	Automatic	±15	±20	9	14	±56	From +40 to -42	±56	From +56 to -42
ATMOSPHERICS	Manual	±30		6					
MLA	Automatic	±30		6		±56	From +1.5 to +40	±56	From -1 to +56
	Manual								
LA	Automatic	±30		6		None	Fixed	±56	From +56 to -42
	Manual						-0.4 to -0.5		

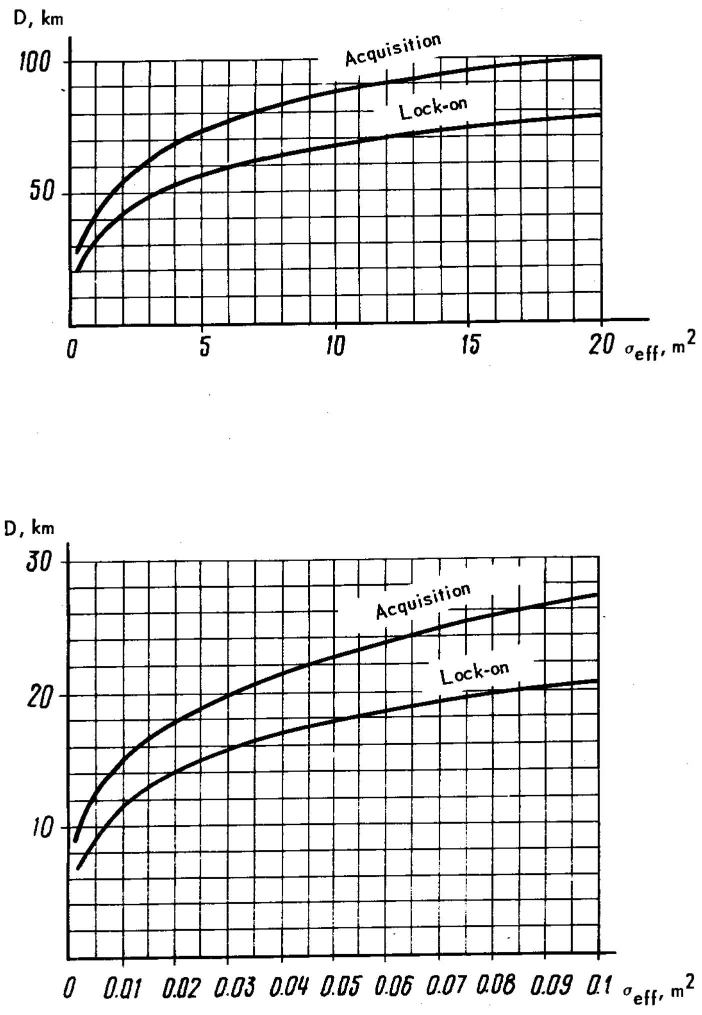


FIG. 4. CURVES ILLUSTRATING DEPENDENCE OF TARGET ACQUISITION AND LOCK-ON RANGE ON TARGET EFFECTIVE REFLECTING SURFACE IN "HMA" MODE

head, when the continuous illumination channel is operating for radiation);

- direction of the airborne radar antenna to the target with subsequent changeover to operation with the radar sight.

In case of failure of the airborne radar, the heat direction finder makes it possible to launch the missiles in the "φ_o" mode.

28. The ТП-26Ш1 heat direction finder has five operating modes: T-I, T-II, T-III, T-φ_{oI}, T-φ_{oII}.

29. On the МиГ-25ПД (МиГ-25ПДС) aircraft, the heat direction finder scanning zone is shaded from top through 2^o and relative the aircraft datum line, with the radar operating in the T-I, T-III, T-φ_{oI} modes, has the following sizes in elevation:

- 4^o upward;
- 9^o downward.

While executing an attack, depending on the target range, the pilot should maintain the step-up (step-down) separation so that the target is within the heat direction finder scanning zone. The dependence of the step-up (step-down) separation on the target range is presented in Fig. 5.

The heat direction finder operating altitude ranges from 200 to 25,000 m.

The heat direction finder readiness time does not exceed 5 minutes.

30. The heat direction finder operating modes are selected depending on the given situation and are employed in the following cases:

- the T-I mode is the main operating mode (the scanning and autotracking mode). This mode is used in the ordinary situation to detect, lock on and aim at a nonmaneuvering target with the subsequent launching of the missiles or change over to operate in conjunction with the airborne radar;

- the T-II mode is a scanning mode. This mode is used for detailing the situation in the area of strobes of the T-I mode.

The mode is employed for discriminating the target against the background of the ground clutter (windows), cloudness or during operation against the group target;

- the T-III mode is an autotracking mode. This mode is used in aiming at a maneuvering target and on the final leg of the attack;

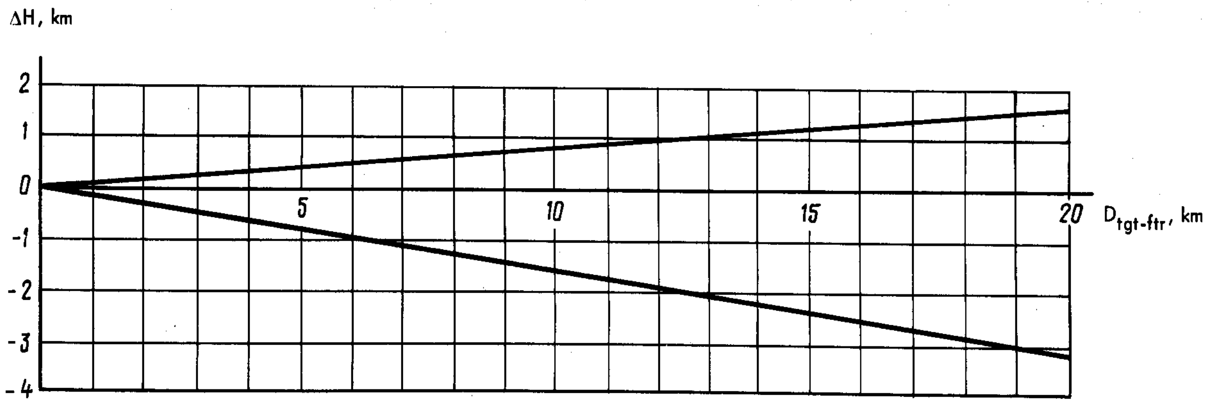


FIG. 5. RANGE OF TARGET RECOVERY FROM SCANNING ZONE OF HEAT DIRECTION FINDER VERSUS STEP-UP (STEP-DOWN) SEPARATION OF TARGET

- the T-φ_{oI} mode is a mode of scanning and aiming along the weapon axis. This mode is used for coarse aiming in the initial stage of the attack in case of failure of the airborne radar;

- the T-φ_{oII} mode is a mode of scanning and aiming along the weapon axis. This mode is used for precise aiming in the final stage of the attack.

31. The ranges of detection and lock-on of the air targets by means of the heat direction finder, depending on the type of the target, its flight altitude and the background, are the following:

(a) for the target, type Ty-16, against the clear sky background in the daytime from the rear hemisphere at an aspect angle of 0/4 to 1/4 and altitudes of 9000 to 12,000 m, with the step-up separation of the fighter relative to the target being up to 3000 m, and the step-down separation, 500 m:

D_{detect} = 32 to 51 mm　　$D_{detect\ mean}$ = 45 km

$D_{lock-on}$ = 28 to 48 km　　$D_{lock-on\ mean}$ = 39 km;

(b) for the target, type МиГ-21, against the terrain background from the rear hemisphere at an aspect angle of 0/4 and altitudes ranging from 500 to 1500 m below clouds:

D_{detect} = 12 to 28 km　　$D_{detect\ mean}$ = 22 km

$D_{lock-on}$ = 11 to 27 km　　$D_{lock-on\ mean}$ = 21 km;

(c) for the target, type Ty-16, against the cloud background in the daytime from the rear hemisphere at an aspect angle of 0/4 to 1/4 and altitudes ranging from 1500 to 6000 m:

D_{detect} = 20 to 28 km　　$D_{detect\ mean}$ = 22 km

$D_{lock-on}$ = 18 to 27 km　　$D_{lock-on\ mean}$ = 21 km;

(d) for the target, type МиГ-25, from the rear hemisphere, with the engines operating at the FULL REHEAT power setting, the detection and lock-on ranges exceed 90 km.

1.3.3. Collimating Sight K-10T

32. The K-10T collimating sight is used for aiming at a visually visible target.

The aiming and determination of the target range are effected with the aid of the sight reticle components (Fig. 6) whose angular sizes amount to:

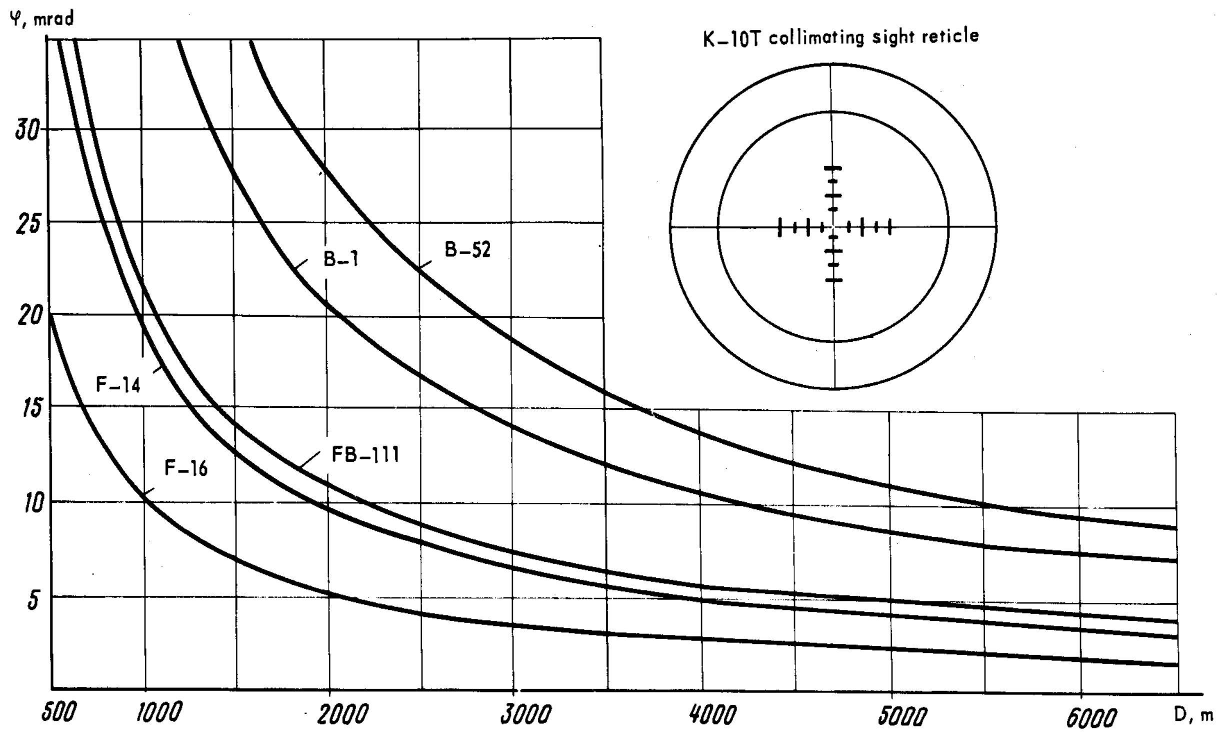


FIG. 6. DEPENDENCE OF TARGET ANGULAR DIMENSIONS ON TARGET RANGE AND SPAN (BASE)
(for aircraft B-1, FB-111, F-14 wing span was taken into account at minimum wing sweepback)

- 120 mrad (mils) - the radius of the large ring;
- 80 mrad (mils) - the radius of the small ring;
- 20 mrad (mils) - the large division;
- 10 mrad (mils) - the small division;
- 11.4 mrad (mils) - the length of the large mark;
- 5.7 mrad (mils) - the length of the small mark.

When launching the missiles in the "φ_0" mode, the sight reticle crosshairs are the point of aiming.

The target range is determined when using the K-10T collimating sight, with the target (span) size known, by the formula:

$$D = \frac{S}{\varphi},$$

where: D is the target range in km;
S is the span (size) of the target in m;
φ is the target angular size in mrad.

The pilot determines the target angular size by reference to the reticle of the K-10T collimating sight, whereas the target span he should bear in mind.

1.4. MISSILE ARMAMENT

33. The armament system of aircraft interception complex МиГ-25-40Д (МиГ-25-40ДС) includes air-to-air guided missiles Р-40РД, Р-40ТД, Р-40Т, Р-60, Р-60М.

Missiles Р-40ТД (Р-40Т) are suspended only from the inboard launchers, and missiles Р-60 (Р-60М) are suspended only from the outboard ones.

1.5. AIRBORNE DIRECTION AND TARGET DESIGNATION EQUIPMENT 5У15К-11

34. The 5У15К-11 airborne direction and target designation equipment is used for receiving the control and direction commands.

The 5У15К-11 equipment ensures solution of the following problems:

- reception of the direction commands from the automated control system ground direction posts;
- decoding, conversion and transmission of the received direction commands to the air data computer system, automatic flight control system and airborne radar.

1.6. INTEGRATED NAVIGATION AND LANDING SYSTEM POLJOT-1И

35. The POLJOT-1И system is used for automating the air navigation and improving the flight safety level. The system solves the problem of the aircraft control automation on the flight path.

Depending on the type of flight, the parameters of the preset flight path are determined by one of the airborne radio systems:

- the 5У15К-11 airborne direction and target designation equipment - at the stage of the ground-based direction;
- the SAPFIR-25 airborne radar - at the stage of guidance from the fighter and homing;
- the PCБH-6C short-range radio navigation and landing system - at the stage of the en-route flight, return to the programmed airfield and approach for landing.

36. The POLJOT-1И system makes it possible to solve the following air navigational and piloting problems:

- determination of the angular spatial attitude of the fighter in the vertical and horizontal planes (roll, pitch, present course, selected course, radio beacon relative bearing);
- determination of the parameters of the aircraft motion (the relative and absolute altitudes, true airspeed, Mach number);
- determination of the range to the airfield or to the programmed route waypoint;
- return of the aircraft to the landing airfield from any stage of the flight;
- accomplishment of the assigned en-route flight;
- interception of the runway heading with the simultaneous descent from the cruising altitude to an altitude of the intermediate approach;
- providing the aircraft entry into the zone of the localizer and glideslope beacons of the landing airfield and descent to an altitude of 40 to 60 m;
- increase in accuracy of execution of the maneuvers in guidance on a target;
- stabilization of the aircraft yaw, altitude, selected angles of roll and pitch;
- damping of the aircraft natural oscillations;

- automatic recovery of the aircraft from the limit altitude by referring to the command signals of the low-altitude radio altimeter with subsequent stabilization of the safe altitude;

- the programmed climbing with subsequent interception of the selected altitude or Mach number and their further stabilization.

In absence of the rho-theta radio beacon signals delivered to the РСБН-6С system, the coordinates are computed autonomously by referring to the airspeed and course by the air data computer and directional/vertical gyro systems.

The POLJOT-1И integrated system allows the pilot to control the aircraft in the automatic, director and manual modes.

37. The POLJOT-1И integrated navigation and landing system incorporates the following:

- the САУ-155ПДБ automatic flight control system for the МиГ-25ПД aircraft and the САУ-155П1ДБ for the МиГ-25ПДС aircraft;
- the СКВ-2НЛ-2 directional/vertical gyro system;
- the СВС-ПН-5-84А-series 2 air data computer system;
- the РСБН-6С short-range radio navigation and landing system.

1.6.1. Automatic Flight Control System

38. The САУ-155 automatic flight control system is used for controlling the fighter in the automatic and director modes at the various power settings and flight stages, as well as for increasing the flight safety and improving the stability characteristics in the manual modes of aircraft piloting within the range of employment of the МиГ-25ПД aircraft with symmetrical and asymmetrical variants of suspension of the external stores. This is achieved by execution of both the autonomous (autopilot) and external functions by the automatic flight control system.

39. Among the autonomous functions of the automatic flight control system are:

- damping of the short-period yaw, roll and pitch oscillations;

- stabilization of the roll and pitch angles, with the control stick released, within ± 7 to 80° and ± 0 to 85°, respectively, as well as the course within the angles of roll of ± 0 to 7° and pitch of ± 0 to 40°;

- stabilization of the assigned Mach number and barometric altitude of flight;

- the aircraft automatic levelling from any attitude with subsequent stabilization of the altitude and course throughout the entire range of airspeeds with the symmetrical variants of the external stores, and at Mach numbers of not more than 2.5, with the asymmetrical variants of the external stores;

- counteraction of the momentary disturbances in launching the missiles in the DAMPER (ДЕМПФЕР) mode throughout the entire range of combat employment, and during the automatic control, up to M = 2.5.

Among the external functions of the automatic flight control system are:

- the ground direction with the manual input of M_N and H_{lvl} values;

- homing and recovery from the attack during interaction of the automatic flight control system with armament control system C-25;

- recovery from the limit altitude in response to the radio altimeter command in the stages of the ground direction and homing at the initial roll angles up to 30°;

- the director and automatic control of the aircraft in the following modes:

(a) en-route flight;

(b) return to the landing airfield;

(c) intermediate approach;

(d) landing approach to an altitude of 40 to 60 m;

(e) repeated approach.

The autonomous and external functions are accomplished by the automatic flight control system in the automatic and director control modes with delivery of the control signals to the command bars of the КПП flight director indicator and to the integrated display system indicator in case of integration of the automatic flight control system with the following main systems:

- the PB-15 (ВЕРЕВ-М) radio altimeter;

- the СВС-ПН-5-84А-series 2 air data computer system;

- the СКВ-2НЛ-2 directional/vertical gyro system;

- the РСБН-6С short-range radio navigation and landing system;

- the SAPFIR-25 airborne radar;

- the 5У15К-11 airborne direction and target designation equipment;

- the АРК-19 (АРК-10 for the МиГ-25ПДС fighter) automatic direction finder.

40. In flight, the automatic flight control system, irrespective of the selected mode, computes the tolerable values of the normal g-load, angle of attack, maximum and minimum indicated airspeeds. When the aircraft reaches the limit values of the normal g-load, angle of attack, maximum indicated airspeed, the automatic flight control system delivers the light and voice information, and when the aircraft reaches the limit values of the minimum indicated airspeed, only the voice information is delivered by the system.

41. The most complete use of all the functional capabilities of the automatic flight control system ensures:

- increase of the flight safety in all the modes both in the VFR and IFR conditions;
- increase of the efficiency of the pilot's actions and decrease of his fatigue in flight;
- increase in the efficiency of combat employment of the aircraft missile interception complex at the stages of the ground and air guidance;
- improvement of the aircraft stability characteristics in the manual modes of piloting;
- decrease in the weather "minimum" of the aircraft during the landing approach.

1.6.2. Directional/Vertical Gyro System СКВ-2НЛ-2

42. The СКВ-2НЛ-2 directional/vertical gyro system is used for measurement of the roll and pitch angles and the great circle course of the aircraft and continuous delivery of their values to the КПП flight director indicator and the НПП combined course indicator, as well as to the other systems.

The directional/vertical gyro system ensures delivery of the yaw and pitch signals without limitations, and the roll signals, within the pitch angles of $\pm 80^{\circ}$.

43. The error in determining the roll and pitch angles in the straight-and-level flight should not exceed $\pm 0.5^{\circ}$.

The error after accomplishment of the 360° banked turns and aerobatics should not exceed $\pm 2^{\circ}$. The error in computing the course with due allowance for precise deviation and introduction of magnetic declination under conditions of the straight flight at a constant airspeed should not exceed $\pm 1.5^{\circ}$.

1.6.3. Air Data Computer System СВС-ПН-5-84А-Series 2

44. The СВС-ПН-5-84А-series 2 air data computer system is used for continuous measurement of the values of true airspeed, true barometric altitude, relative barometric altitude, Mach number, deviations of the true barometric altitude from the preset value (within $\Delta H = \pm 400$ to 1500 m) and delivery of these parameters to the automatic flight control system, short-range radio navigation and landing system, airborne radar, directional/vertical gyro system, СО-69 ATC transponder and their display.

45. The errors in delivery of the altitude and airspeed parameters are as follows:

(a) Mach number:

- ± 0.02 at altitudes less than 20,000 m and $M \leq 1.5$;
- ± 0.04 at altitudes less than 20,000 m and $M > 1.5$;
- ± 0.06 at altitudes ranging from 20,000 to 25,000 m;

(b) true airspeed:

- ± 15 km/h + 0.01 V_{pres} at altitudes not more than 20,000 m;

(c) relative barometric altitude:

- ± 30 m at altitudes not more than 1000 m;
- ± 60 m at altitudes ranging from 1000 to 10,000 m;
- ± 100 to 200 m at altitudes ranging from 10,000 to 20,000 m;

(d) true barometric altitude:

- ± 30 m + 0.03 H_{pres} at altitudes more than 3000 m;
- ± 60 m + 0.03 H_{pres} at altitudes less than 3000 m.

While in flight, the following parameters are displayed on the indicators of the air data computer system:

(a) on the УВО-М1 altimeter:

- the relative barometric altitude;
- the barometric pressure of the day on the departure or landing airfield;
- the preset flight altitude;

(b) on the УСО-М1 airspeed and Mach number indicator:

- the true airspeed;
- the Mach number;
- the preset Mach number.

1.6.4. Airborne Short-Range Radio Navigation and Landing System РСБН-6С

46. The РСБН-6С system is a complex of the radio means ensuring the computation of the aircraft present coordinates

with the delivery of information on the aircraft spatial attitude, construction of the flight path curve and shaping of the control signals at the following stages of flight:

- programmed en-route flight;
- return of the aircraft to the programmed landing airfield;
- flight at the cruising altitude and cloud break-out down to an altitude of 630 ±30 m;
- execution of the intermediate approach;
- landing approach to an altitude of 60 m;
- repeated landing approach;
- return and landing on the non-programmed airfield.

47. The РСБН-6С system is used for:

- computation of the preset course in executing the en-route flight;
- computation of the aircraft flight path of return to any of four programmed airfields at an altitude of 9500 m from a distance of less than 250 km from the radio beacon as well as computation of the intermediate approach path at an altitude of 630 ±30 m;
- computation of the left-circle repeated landing approach path at an altitude of 630 m;
- measurement and display of the distance (on the ППД-2 range indicator) to the programmed route waypoint;
- measurement and display of the aircraft azimuth (on the НПП combined course indicator) with respect to the radio beacon;
- computation and display of the radio beacon relative bearing (on the НПП combined course indicator);
- listening of the РСБН-2Н (4Н) navigation radio beacons call signs through the pilot's headphones.

48. In the process of operation the РСБН-6С system operates in conjunction with the following ground facilities:

- the rho-theta radio navigation beacon of the РСБН-2Н or РСБН-4Н system:
- the localizer and glideslope radio beacons of the ПРМГ-4 system;
- the retransmitter of the landing distance measuring equipment of the ПРМГ-4 system.

The РСБН-2Н (4Н) ground system ensures for the РСБН-6С system the continuous computation of two coordinates of the aircraft - the azimuth and the slant distance to the ground radio beacon, which makes it possible to correct operation of the autonomous airborne computer.

The joint operation of the ПРМГ-4 system and the POLJOT-1И integrated system makes it possible, after the entry of the aircraft into the airfield zone at the intermediate approach altitude, to accomplish the automatic or director control approach up to an altitude of 50 to 60 m.

49. The РСБН-6С system operates in the following modes:

- air navigation (the programmed en-route flight);
- aircraft return to the landing airfield;
- landing.

The computation of the flight path and signals of deviation from the flight path in the above-mentioned modes is effected by the system in compliance with the assigned program which is introduced into the РСБН-6С system. The scope of the program introduced into the system is as follows:

- three waypoints;
- four landing airfields.

The coverage of the РСБН-6С system in the radio updating mode, depending on the flight altitude, amounts to:

- 450 km at an altitude exceeding 20,000 m;
- 360 km at an altitude of 10,000 m;
- 250 km at an altitude of 5000 m;
- 110 km at an altitude of 1000 m;
- 50 km at an altitude of 250 m.

50. The РСБН-6С system ensures the following accuracy in controlling the aircraft:

(a) deviation from the selected altitude:

- not more than ±500 m at the cruising altitude (9500 m);
- not more than ±30 m at the intermediate approach altitude (630 m);

(b) errors in measuring the azimuth and distance amount to $\pm 0.25^\circ$ and ±284 m, respectively;

(c) error in alignment with the runway at a distance of 20 km from the landing airfield does not exceed ±500 m.

1.7. RADIO COMMUNICATION AND RADIO NAVIGATION EQUIPMENT OF AIRCRAFT

1.7.1. Aircraft Communication Equipment

51. The ultra-short wave transceiving communication radio set is used for establishing the two-way radiotelephone communi-

cation between the aircraft and the ground communication posts (stations) as well as between the aircraft.

The radio set may be preliminarily tuned to 20 channels (fixed frequencies) on the ground. The time of changeover from one channel to the other does not exceed 1.5 s.

When the airborne radio set operates in conjunction with the ground radio stations, it ensures the following ranges of two-way radio communication:

- not less than 120 km at an altitude of 1000 m;
- not less than 350 km at an altitude of 10,000 m.

When the radio set operates for establishing the communication between the aircraft, it ensures the two-way radio communication at a range of not less than 150 km at the flight altitude more than 1000 m.

52. The short-wave communication radio set is used for establishing the long-range radio communication (free from fine tuning) with the ground radio stations and between the aircraft. The radio set may be preliminarily tuned to 10 channels on the ground. The time of retuning from one channel to the other is not more than 5 s.

The radio set ensures the communication range up to 1000 km.

1.7.2. Navigation and Landing Equipment of Aircraft МиГ-25ПД (МиГ-25ПДС)

53. The navigation and landing equipment installed on the МиГ-25ПД and МиГ-25ПДС aircraft is similar with the exception of the automatic direction finder. The МиГ-25ПД aircraft is furnished with the АРК-19 automatic direction finder, and the МиГ-25ПДС aircraft, with the АРК-10 automatic direction finder.

The automatic direction finder is used for air navigation by signals delivered from the homing and broadcasting radio stations and radio beacons.

The coverage of the АРК-19 automatic direction finder in conjunction with the ПАР-8 homing radio station is:

- not less than 180 km at an altitude of 1000 m;
- not less than 340 km at an altitude of 10,000 m.

The automatic direction finder may be preliminarily tuned to the frequencies of the homing radio stations of four airfields. The time required for retuning from one station to another one does not exceed 4 s.

The АРК-10 automatic direction finder coverage, with the aircraft flying at an altitude of 1000 m, amounts to (for frequencies within 400 to 600 kHz):

- 150 to 200 km when operating in conjunction with the ПАР-8 and ПАР-ЗБМ homing radio stations;

- 250 to 300 km when operating in conjunction with the ПАР-7 homing radio station;

- 320 to 350 km when operating in conjunction with the ПАР-8С homing radio station.

54. The А-031 radio altimeter is used for measuring the absolute flight altitude within 0 to 1500 m and ensures:

- the continuous automatic delivery of the altitude data to the А-031-4 altitude indicator and to the display channel of the airborne radar;

- the light indication and the LIMIT ALTITUDE (ОПАСНАЯ ВЫСОТА) voice information when descending below the preset limit altitude;

- the LIMIT ALTITUDE signal delivery to the automatic flight control system to automatically recover the aircraft from the limit altitude.

55. The МРП-56П marker receiver is used for receiving the marker radio beacon signals and for warning the pilot when the aircraft flies over the points located at certain distances from the runway (over the outer and inner marker radio beacons).

56. The СО-69 aircraft transponder serves for solving the following problems:

- increase of coverage of the ground radars in determining the aircraft coordinates;

- observation of the fighters under conditions of the ground clutter and atmospheric noise displayed on the ground radar indicators;

- transmission of the aircraft registration number and flight altitude to the airfield air traffic control system;

- identification of the aircraft on the ground radar screens.

The СО-69 aircraft transponder coverage is as follows:

- 320 km at an altitude of 12,000 m when operating in conjunction with the ground radars, type П-35;

- 135 km at an altitude of 4000 m when operating in conjunction with the airfield control radar of the РСП-6 ground controlled approach system;

- 150 km at an altitude of 4000 m when operating in conjunction with the airfield control radar of the РСП-7 ground controlled approach system;

- 50 km at an altitude of 1000 m when operating in conjunction with the precision-approach radar of the РСП-6 ground controlled approach system;

- 60 km when operating in conjunction with the precision-approach radar of the РСП-7 ground controlled approach system.

1.8. GROUND CONTROL AND DIRECTION SYSTEMS

57. The fighter combat actions may be controlled with the use of the automatic control systems.

The control and direction equipment provides for automatic solution of the problems relating to the direction of the fighters to the air enemy and transmission of the computed commands to the fighter.

The fighters may be directed with the aid of the instrument direction equipment and automatic control system.

58. The instrument direction equipment is used for automatic solution of the problem relating to the direction of the fighters to the air targets and computation of the fighter flight control commands as well as the target designation commands for the antennas of the airborne radar sights.

The instrument direction equipment ensures:

- simultaneous instrument direction of two fighters (groups) to two air targets flying at airspeeds ranging from 500 to 3600 km/h at altitudes from 500 to 30,000 m;

- execution of the preliminary navigator's calculations;

- redirection of the fighters on the other targets in the process of direction;

- changeover (takeover) of the fighter control to the cooperating ground control (observation) post;

- bringing of the fighters to the coverage area of the landing aids of the airfield;

- automatic transmission of the control and target designation commands to the fighter with the aid of the LAZUR (LAZUR-M) equipment;

- reception and representation of the primary radar information on the air situation in a radius of 600 km;

- training of the combat crew.

The safety of the fighters to be directed is ensured by presence of the primary radar information and by the profound knowledge of the flight safety instructions by the combat crew.

1.9. GROUND RADAR AIDS

59. Radar complex 5H87 is used for executing the radar reconnaissance and ensuring the control and direction of the fighters.

Radar complex 5H87 includes:

- two ranging radars;
- two to four radio altimeters ПРВ-13.

The combat capabilities of radar complex 5H87 in detecting the targets and computing the coordinates are characterized by the range-finding channel visibility zones and the identification zone.

The ranges of acquisition of the targets having the different effective reflecting surfaces for the various altitudes are given in Table 8.

The ranges of acquisition of the targets having the effective reflecting surface of 1 m^2 in area for the various altitudes by the ПРВ-13 radio altimeter are given in Table 9.

The visibility zone with respect to identification is shaped by the antennas of the upper and lower angles of the range finder with the identification limits equalling:

- from 0.5 to 45° in elevation;
- from 0 to 360° in azimuth.

The identification zone in the single-channel and two-channel interrogation modes of the KREMNIY-2 radar identification system is not worse than the visibility zone of the range-finding and altitude-measuring channels of the radar complex.

The accuracy in measuring the radar information amounts to:

Table 8

Target flying altitude, m	Acquisition range, km		
	σ = 0.3 m^2	σ = 1 m^2	σ = 10 m^2
5000	180	180	180
10,000	240	280	300
15,000	240	340	370
20,000	240	340	430
25,000	240	340	480
30,000	240	340	530

Table 9

Value to be measured	Range-finding mode (antenna scanning speed - 6 rev/min, dead angle - 0°) at flying altitude, m					Altitude-measuring mode (dead angle - 0°) at flying altitude, m		
	50	100	300	500	1500	200	400	More than 6000
Acquisition range, km	32	42	65	85	140	50	200	310

- ±1500 m in range;
- ±0.8° (of the range finders) and 0.2° (of the altimeters) in azimuth;
- ±300 m (at a distance of less than 200 km) and 500 m (at a distance of more than 200 km) in altitude.

The radar complex resolving powers with respect to the targets having the effective reflecting surface of 1 m^2 in area are given in Table 10.

Table 10

Coordinates	Resolving power with respect to coordinates	Indicator scale, km
In range:		
- range finders	1400 m	200
- altimeters	2000 m	150
In azimuth:		
- range finders	1°	200
- altimeters	3°	300
In elevation	1°	34
In altitude	4000 m	At a distance of 200 km

Provision is made in radar complex 5H87 for its protection against the homing missiles and the following kinds of jammings:
- barrage and spot active noise jammings;
- active repeater discontinuous jammings;

- passive jammings;
- asynchronous discontinuous jammings.

60. Radar station П-37 is used for executing the radar reconnaissance and ensuring the control and direction of the air-defence fighters.

The ranges of acquisition of the air targets having the different effective reflecting surface for the various altitudes by the radar station are given in Table 11.

Table 11

Target flying altitude, m	Acquisition range, km		
	$\sigma = 0.3\ m^2$	$\sigma = 1\ m^2$	$\sigma = 10\ m^2$
200	-	35	-
300	-	40	-
400	-	45	-
500	35	50	60
12,000	135	180	250
18,000	-	180	250
20,000	-	-	250
30,000	-	-	240 (with dead zones)

The accuracy in measuring the radar information is as follows:
- ±500 m in range;
- not more than 0.5° in azimuth.

The resolving powers:
- 500 m in range;
- 1 to 1.5° in azimuth.

Provision is made in the radar station for its protection against the homing missiles and the following kinds of jammings:
- active jammings;
- passive jammings;
- asynchronous discontinuous jammings.

61. The П-18 radar station is used for executing the radar reconnaissance and may be used for controlling and directing the fighters.

The visibility zone of the П-18 radar station is determined by the antenna lift height (3.9 or 7.9 m) and the nature of the site on which the radar station is deployed.

The ranges of acquisition of the air targets (in absence of jammings) having the different effective reflecting surface for the various altitudes by the radar station are given in Table 12.

Table 12

Target flying altitude, m	Acquisition range, km			
	$\sigma = 0.3\ m^2$		$\sigma = 1\ m^2$	
	$h_{ant} = 3.9$ m	$h_{ant} = 7.9$ m	$h_{ant} = 3.9$ m	$h_{ant} = 7.9$ m
100	21	24	28	30
300	29	37	40	50
500	37	44	50	60
1000	48	54	65	80
5000	106	124	145	170
10,000	128	183	175	250
16,000	150	191	205	263
20,000	168	198	230	270
30,000	168	198	250	270

The errors in determining the coordinates of the target are as follows:

- 1800 m in range;
- 1.5^{o} in azimuth;

The resolving powers:

- 2000 m or better in range;
- 6 to 8^{o} in azimuth.

Provision is made in the radar station for its protection against the homing missiles and the following kinds of jammings:

- active jammings;
- passive jammings;
- asynchronous discontinuous jammings.

Chapter 2

COMBAT CAPABILITIES OF AIRCRAFT INTERCEPTION COMPLEX МиГ-25-40Д (МиГ-25-40ДС)

2.1. ALTITUDE AND AIRSPEED RANGE OF TARGETS TO BE DESTROYED

62. The altitude and airspeed range of the targets to be destroyed (Fig. 7) depends on the fighter performance and power-ballistic characteristics of the missiles.

63. The maximum altitude of the targets to be destroyed depends on the maximum reference altitude of the МиГ-25ПД (МиГ-25ПДС) fighter and power-ballistic characteristics of the missiles.

Assumed as the maximum reference altitude is the maximum flight altitude at which combat maneuvering for the aiming zoom is possible.

64. The maximum reference altitude of the МиГ-25ПД (МиГ-25ПДС) fighter equals to 20,000 m.

65. The Р-40Д missile has the highest power-ballistic characteristics. It is capable of destroying the targets flying 10,000 to 12,000 m above the fighter (Fig. 8). With the fighter flight altitude taken into account, the maximum target elevation above the fighter is changed and calculated by the following formula:

$$\Delta H_{max\ 1} = \begin{cases} 2 + 0.2H_{ftr} & \text{at } H_{ftr} \leq 10 \text{ km} \\ 4 + 0.8\,(H_{ftr} - 10) & \text{at } H_{ftr} > 10 \text{ km,} \end{cases}$$

where $\Delta H_{max\ 1}$ is the maximum target elevation above the fighter in km;

H_{ftr} is the fighter flight altitude in km.

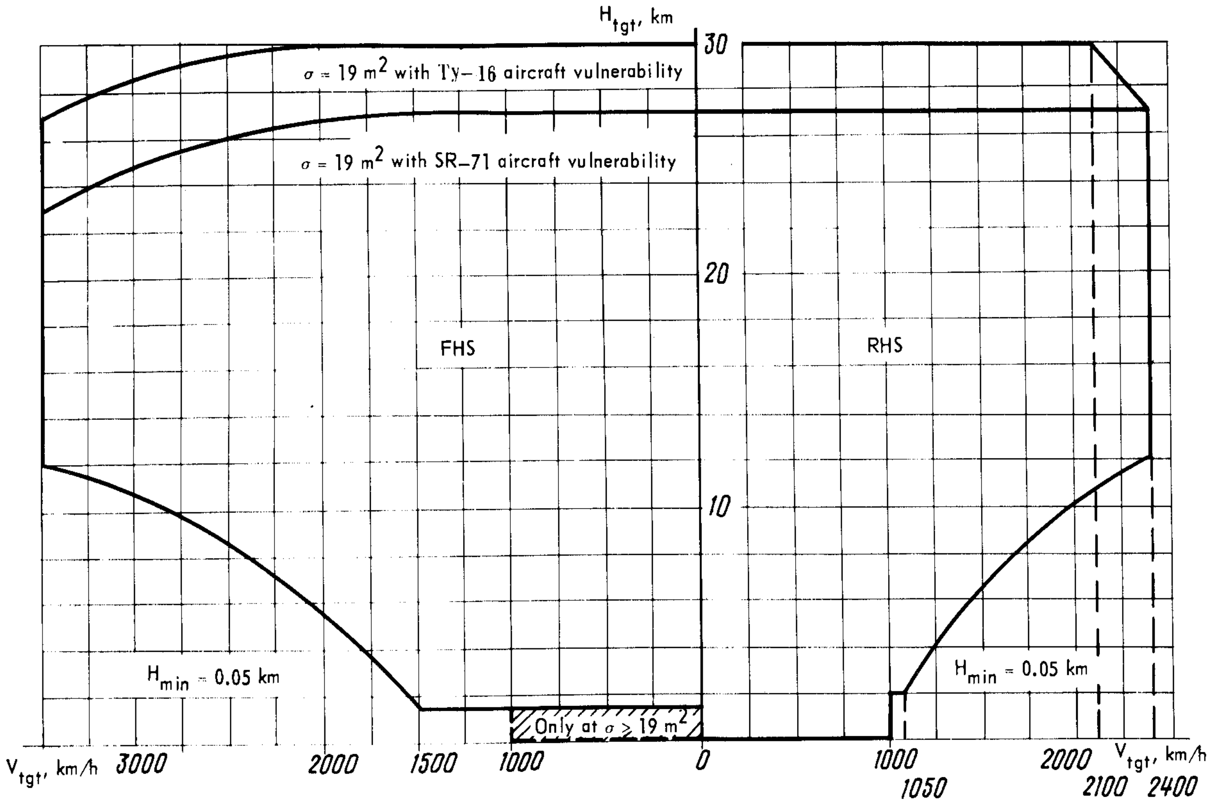


FIG. 7. RANGE OF ALTITUDES AND AIRSPEEDS OF TARGETS TO BE HIT

At the end of the aiming zoom the missiles are launched either into the front or aft hemisphere, the maximum altitude of the destroyed targets being equal to 30,000 m.

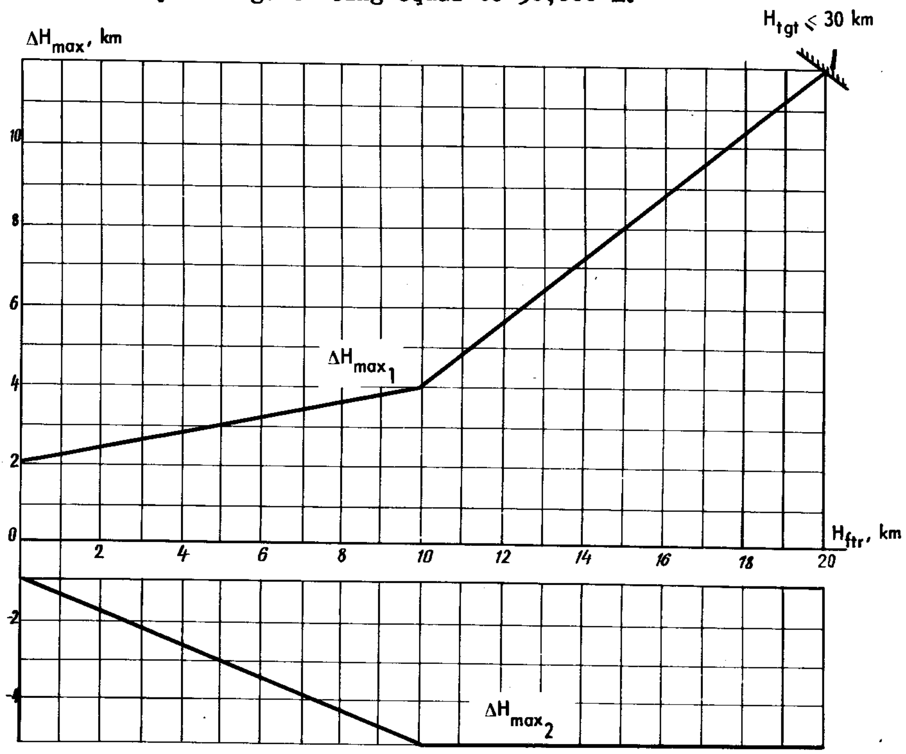


FIG. 8. PERMISSIBLE STEP-UP (STEP-DOWN) SEPARATION OF TARGET RELATIVE TO FIGHTER FLIGHT ALTITUDE IN LAUNCHING MISSILES P–40Д

66. In the attack at a step-down vertical separation with respect to the target, the minimum altitude of the targets to be destroyed is reduced by the ground clutter, that, as the flight altitude decreases, intensively jam the indicator screen of the airborne radar with blind or dotted clutter, hindering the target acquisition and lock-on. The adverse effect of the clutter depends on the flight altitude of the target and fighter, target range and underlying surface. In this mode when launching the rear-cone attack, the minimum altitude of the targets to be destroyed makes

up 600 m. When the attack is launched into the forward hemisphere, the target minimum flight altitude is limited by the time at the pilot's disposal from the moment of acquisition till launch and makes up 1500 m.

When the target is attacked against the ground background (the LA (MB) mode), the minimum altitude of the targets to be destroyed is limited by the missile radio fuze operation altitude in response to the ground signals (clutter) and makes up 50 m.

67. The P-40Д missile makes it possible to launch an attack when the fighter is flying above the target. The maximum elevation of the fighter above the target during the launch makes up 5000 m.

The maximum elevation of the fighter above the target at which the target hitting is ensured, depends on the fighter flight altitude and is calculated by the formula:

$$\Delta H_{max\ 2} = \begin{cases} 1 + 0.4H_{ftr} & \text{at } H_{ftr} \leqslant 10 \text{ km} \\ 5 & \text{at } H_{ftr} > 10 \text{ km,} \end{cases}$$

where $\Delta H_{max\ 2}$ is the maximum elevation of the fighter above the target in km;

H_{ftr} is the fighter flight altitude in km.

68. When the target is attacked into the aft hemisphere, the maximum airspeed of the target to be destroyed is determined by the airspeed and fuel reserve of the fighter, making it possible to pursuit and destroy the target at the assigned line with an estimated probability.

The airspeed is calculated by the formula:

$$V_{tgt} = \frac{V_{ftr}}{1.2},$$

where V_{tgt} is the maximum airspeed of the targets to be destroyed;

V_{ftr} is the fighter airspeed. At altitudes of up to 11,000 m the airspeed is assumed equal to the maximum true airspeed, at altitudes higher than 11,000 m, the optimum climb-program airspeed.

The given relation between the airspeeds of the fighter and target is an optimum. It ensures the most probable direction.

The said limitations taken into account, the maximum airspeed of the targets to be destroyed makes up:

- 1000 km/h at low altitudes;
- 2400 km/h at altitudes from 12,000 to 27,000 m.

When the target is attacked into the front hemisphere, the maximum airspeed is limited by the time at the pilot's disposal for aiming, the missile available load factor, maximum angular velocity of the airborne radar antenna and missile coordinator, maximum relative closure speed required for coordinating the fuze operation area and the missile warhead with the target.

With allowance made for the said limitations, the maximum airspeed of the targets to be attacked into the front hemisphere makes up 3500 km/h at altitudes of 12,000 to 27,000 m and 1500 km/h at an altitude of 1500 m.

69. With the airborne radar operating at any mode, the minimum airspeed of the targets to be destroyed is not limited. In the LA (MB) mode, the minimum speed is limited by the projection of the target speed vector on the fighter-target line of sight, that is

$$V'_{tgt} = V_{tgt} \cos q,$$

$$V_{tgt} \cos q \geqslant 75 \text{ km/h},$$

where $\cos q$ is the aspect of attack;

V'_{tgt} is the projection of the target speed vector on the fighter-target line of sight, km/h;

V_{tgt} is the target speed, km/h.

2.2. COMPLEX EFFECTIVENESS

70. The combat effectiveness of the complex can be evaluated by the probability of launching of the air target attack, which depends on the following factors:

- flight performance of the fighter;
- type of the target (the target effective echoing area, size, vulnerability);
- experience and training level of the pilots, air navigators and engineering personnel;
- capabilities of the ground radars, data transmission and display means, training level of the teams of these means;
- operational reliability of all technical means ensuring the performance of the air combat with the target attack.

With the complex reliability taken into account, the probability of the performance of the air combat with the target attack is determined by the formula:

$$W_{atk} = K_{reliab} \; W_{dir} \; W_{destr},$$

where K_{reliab} is the complex reliability coefficient;

W_{dir} is the probability of the fighter direction without regard for its reliability;

W_{destr} is the probability of target destruction by two missiles without regard for the missile reliability.

The effectiveness properties of the complex are as follows:

- probability of performance of the attack into the front hemisphere with launching two P-40Д missiles at non-maneuvering targets, type Ty-16, at an altitude of 27 km and at targets, type SR-71, at an altitude of 23 km flying at an airspeed of 3500 km/h is at least 0.7;

- probability of launching the attack into the front hemisphere of non-maneuvering strategic ($\sigma_{eff} = 19\ m^2$) targets vulnerable as targets, types SR-71 and Ty-16, flying at an altitude of 30 km and an airspeed of 3500 km/h is:

  - 0.2 to 0.3 when launching two P-40РД missiles;
  - 0.3 to 0.5 when launching two P-40ТД missiles;
  - 0.5 to 0.65 when launching four P-40Д missiles;

- probability of executing the attack into the rear hemisphere with the launch of two P-40Д missiles at non-maneuvering targets, type Ty-16, flying at an altitude of 30 km and an airspeed of 2400 km/h exceeds 0.7;

- probability of executing the attack into the front hemisphere with the launch of two P-40Д missiles at a small-size ($\sigma_{eff} = 0.5\ m^2$) non-maneuvering target, flying at an altitude of 20 km and an airspeed of 2000 km/h (2400 km/h when attacking into the rear hemisphere), is not less than 0.7;

- probability of executing the attack into the front and rear hemispheres with the launch of two P-40Д missiles at strategic ($\sigma_{eff} = 19\ m^2$) targets and into the rear hemisphere of tactical ($\sigma_{eff} = 3\ m^2$) targets flying at an altitude of 50 m and an airspeed of up to 1000 km/h under conditions of the continuous radar field is not less than 0.7;

- probability of executing the attack into the front hemisphere at an altitude of 10 to 15 km with the launch of two P-40Д missiles at the targets, performing a maneuver, type "breakaway", at a g-load of 1.5 at the stage of airborne guidance, the maneuver being started at a range of not more than 35 km and the fighter-to-target speed ratio being not less than 1.2, is not less than 0.8;

- probability of launching the attack of the target (σ_{eff} = 5 m^2, H_{tgt} = 22 km, V_{tgt} = 2400 km/h) at an aspects of up to 4/4 is not less than 0.89.

In case of launching of two P-40Д missiles, the МиГ-25-40Д (МиГ-25-40ДС) complex ensures performance of the attack against a single non-maneuvering air target, when guidance is carried out from the ground automatic control systems, with the fighter controlled in the automatic, director and manual modes within the range of the target airspeeds and altitudes given in Fig. 7. The air target attack is ensured within the said altitudes and airspeeds range without allowance for the complex reliability at a probability of not less than 0.7. When the target airspeed is lower than 500 m, the complex ensures the attack, provided the radar field is continuous.

However, the said probabilities of performance of the air target attack are ensured when there is no radiocontrast cloud between the fighter and the target in the process of the attack. In case of the radiocontrast cloud cover, when it is impossible to use the HMA and HMA-ΔH (БCB, БCB-ΔH) modes due to the heavily jammed screen, use a special airborne radar mode (ATMOSPHERICS (MПX)). In this case, the capabilities of the sighting system in acquisition and lock-on of the target are substantially lower (1.5 to 2 times as lower) and, consequently, the capabilities of the complex decrease due to limitation of time for the attack, increase of errors in target designation of the airborne radar and inoperability of the infrared missiles.

2.3. CAPABILITIES OF DESTRUCTION OF MANEUVERING AIR TARGETS

71. The armament system of the МиГ-25ПД (МиГ-25ПДС) aircraft ensures launching of the attack against targets maneuvering in course (S-turns, turns), altitude (climb, descent) and speed. When the target maneuvers in altitude, the airborne radar automatically changes over to any operating mode in compliance with the mutual position of the fighter and the target.

The fighter armament system makes it possible to destroy targets maneuvering at g-load of up to 4g with the P-40Д missiles and those maneuvering at g-load more than 8g with the P-60 missiles.

2.4. CAPABILITIES OF DESTRUCTION OF GROUP AIR TARGETS

72. The possibilities of selection of one aircraft from the group target are determined by a resolving power of the airborne radar, heat direction finder and missile homing heads.

The airborne radar resolving power in range depends on the radar operating mode, the indicator screen scale and it is given in Table 13. The resolving power of the airborne radar in azimuth in all modes is 1.5°.

The resolving power of the heat direction finder in azimuth and elevation is $20'$.

The interval between the targets in the group, at which they are clearly visible on the integrated display screen, depends on the target range and is shown in Fig. 9.

Table 13

Airborne radar operating mode	Scale of range scale, km	Resolving power in range, m
HMA	120	1400
HMA	60	1000
HMA-ΔH	60	550
ATMOSPHERICS	60	550
MLA	30	350
LA	30	350

73. To launch an attack against one target from the group, the pilot should discriminate the selected target and lock it on. In this case, the airborne radar steadily tracks the target, making it possible for the pilot to launch the infra-red and radar homing missiles. If the interval and distance between the targets make it impossible to discriminate the selected target and the pilot performs the lock-on, the airborne radar will track power mid-point, formed as a result of composition of the signals returned from the whole group of the aircraft. In this case, the airborne radar antenna will hunt among the aircraft bearings that may result in the autotracking failure.

In case of a group air target, first of all it is recommended to use the infra-red homing missiles. A narrow vision angle of the Р-40ТД missile allows the pilot to precisely aim at one of the aircraft of the group. If several targets will be found in the field of vision of the infra-red homing head at the moment of launch, the head selects one target with the most powerful heat radiation upon approaching the group.

The radar homing missiles should be used against a group target at a minimum possible range.

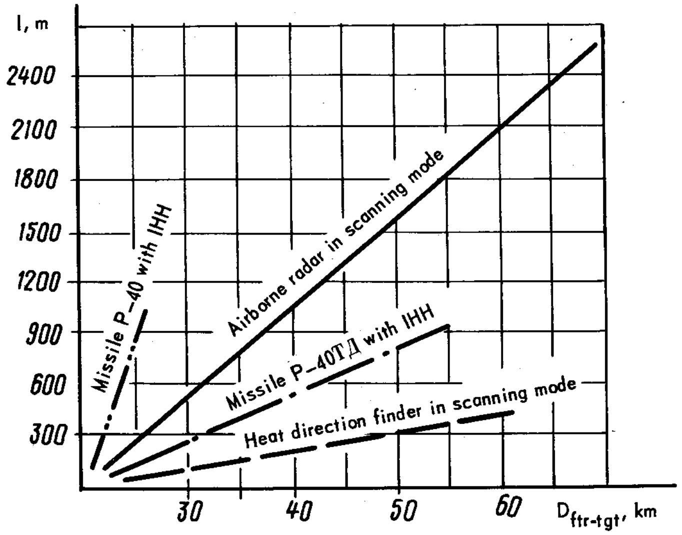


FIG. 9. GROUP AIR TARGET RESOLUTION INTERVALS

2.5. CAPABILITIES OF DESTRUCTION OF LOW-SPEED LOW-ALTITUDE AIR TARGETS

74. The complex ensures the attack of low-speed low-altitude air targets (helicopters, parachute targets, etc.) in all designed operating modes provided the FHS - LST - RHS (ППС - МСЦ - ЗПС) selector switch is set to the LST position to cut off the airspeed selection circuit in the airborne radar. In this case, in the process of executing the attack, false lock-on or change-over to tracking of a false target may occur (when the indicator displays

additional lock-ons in the target area). In this case, the pilot should repeatedly lock on the target.

2.6. CAPABILITIES OF DESTRUCTION OF AIR TARGETS AT HIGH ASPECT ANGLES

75. In the HMA, HMA-ΔH and MLA modes the МиГ-25-40Д (МиГ-25-40ДС) complex ensures an all-aspect attack of the targets into the front and rear hemispheres at an altitudes from 1500 to 30,000 m. Depending on the attack aspect and hemisphere the relation between the airspeed of the fighter and that of the target should lay within the limits of:

- 0.8, when attacking into the front hemisphere at aspects of 0/4 to 3/4;
- 0.8 to 1.0, when attacking into the front hemisphere at aspects of 3/4 to 4/4;
- 1.0 to 1.2, when attacking into the rear hemisphere at aspects of 4/4 to 3/4;
- 1.2, when attacking into the rear hemisphere at aspects of 3/4 to 0/4.

In the HMA mode, at altitudes from 500 to 1500 m the attack can be launched at aspects of 0/4 to 4/4 into the rear hemisphere.

In the LA mode, within the altitude range of 50 to 800 m, with the target optimum step-down separation of 500 m taken into account, the complex ensures launching of the attack at aspects of 0/4 to 1/4 into the target rear hemisphere. In this range, the attack can be launched against big targets at an aspect of 0/4 to 1/4 into the front hemisphere.

2.7. CAPABILITIES OF DESTRUCTION OF TARGETS FLYING BELOW FIGHTER

76. The armament system of the МиГ-25ПД (МиГ-25ПДС) aircraft makes it possible to destroy the air targets flying below the fighter when the latter is up to 5000 m above the target. In this case, with the flying altitude of the fighter and that of the target taken into account, the airborne radar can operate in the HMA-ΔH and LA modes.

The HMA-ΔH mode is used when the target flies at altitudes higher than 1500 m. In this mode the attack can be launched into the front and rear hemispheres of the target flying at an altitude not less than 2000 m and only into the rear hemisphere of the target flying within the altitude range of 1500 to 2000 m.

The LA mode is used when the target flying altitude is low (up to 800 m). The optimum elevation of the fighter above the target is 500 m. The target can be attacked into the rear hemisphere and, if the target is big, into the front hemisphere.

2.8. CAPABILITIES OF DESTRUCTION OF AIR TARGETS UNDER JAMMING CONDITIONS

77. The C-25 armament control system ensures the accomplishment of the combat mission under the atmospherics and jamming conditions. The jamming may be as follows:

- continuous and intermittent noise jamming of the barrage and spot types, as well as jamming modulated in audio frequency range;
- repeater discrete and multiple jamming, including the range- and speed-distorting jamming, as well as repeater noise jamming;
- continuous and broken (dipole) jamming at various positions of the target and fighter with respect to the jammer;
- flickering jamming;
- combined active and passive jamming;
- polarized jamming;
- specific jamming to MTI channel;
- dummy hot targets shot down.

78. Under the electronic aids jamming conditions, use the following tactical techniques in addition to the jamming protective means:

- covert interception of the possible target detection area by the fighter and short-time cut-in of the airborne radar for radiation;
- attack at high aspects;
- attack of the jammer by the group of fighters at a spread of crystal-controlled frequencies;
- approach and infra-red homing missile attack with the use of the heat direction finder;
- simultaneous attack performed by a pair of fighters from different directions.

Chapter 3

COMBAT EMPLOYMENT TECHNIQUES

3.1. GENERAL

79. The fighter combat employment technique implies the procedure and methods of its application in the accomplishment of a combat mission.

The combat employment techniques are classified by a number of factors. The principal factors to be stated in the commander's decision on combat are as follows:

- the initial position of the fighters prior to committing to combat;
- the number of fighters engaged in the combat mission at one and the same time;
- the method of gaining contact with the enemy.

For the effective employment of the combat capabilities of the fighters the following combat actions techniques can be employed as required by the particular situation:

- commitment to action and destruction of the enemy from the airfield alert;
- commitment to action and destruction of the enemy from the air alert;
- semiautonomous (independent) search and destruction of the air enemy in the assigned area.

In classification of the combat employment techniques the initial position of the fighter is taken as the principal factor. The number of fighters and the technique of gaining contact with the enemy may vary. That is why they are defined concretely in taking the decision on execution of the assigned combat mission.

The choice of the combat employment technique depends on:

- the nature of the assigned combat mission;
- supposed flight parameters of the air enemy;
- distant early warning and comprehensiveness of information on air enemy;
- position of the assigned air target destruction lines;
- capabilities of the control post (guidance post) in direction of the fighters.

The initial position of the fighters before commitment to action is determined mainly by the available range of obtaining of information on targets for ensuring the destruction of the air enemy in the assigned lines.

In addition, the choice of the combat employment techniques depends on the comprehensiveness of enemy information and capabilities of the ground control system. Due to the effect of the said factors the regular, intermittent, discrete information on targets or combination of various types of information may be delivered to the control post (guidance post) and, consequently, to the fighter in the process of gaining contact with the air enemy. This directly exerts an influence upon the regularity and quality of generation of the fighters control commands and, in combination with the capabilities of the control system, determines the technique (method) for the fighters to gain contact with the air targets.

Depending on the particular conditions, the methods of gaining contact with the target may be as follows:

- command (automated, nonautomated) direction;
- target designation search;
- independent search.

The combat employment method may provide for the fighters' actions after gaining contact with the target as well. That is why, the commander's decision on execution of the combat mission should state the combat employment method in close detail, for instance: "Commitment of the pairs of fighters to action from the air alert by the command direction method and destruction of the air enemy in a long-range missile combat".

3.2. COMMITMENT TO ACTION AND DESTRUCTION OF AIR ENEMY FROM AIRFIELD ALERT STATE

80. When using this method, the fighters, being in an appropriate state of readiness at the airfield, take off to destroy the

air target as soon as it is detected by the radio aids or air intelligence. In this case, the main method of gaining contact with the target is a command direction. This method is used in the case when the distant early warning about the air enemy ensures the commitment to action and destruction of the air targets by the fighters at the assigned lines.

This method is the most efficient as to saving the manpower and equipment and it allows the commander to commit to action substantial forces and act through the maximum tactical radius or maximum range. The maximum distant (with respect to the fuel reserve) destruction lines are the range boundary of the fighter combat employment area.

However it is not possible to use this method in any case, especially when the radar information quality and obtaining range are not sufficient, for example, in border (coastal) zones, when acting against high-speed and low-altitude targets.

3.3. COMMITMENT TO ACTION AND DESTRUCTION OF AIR ENEMY FROM AIR ALERT STATE

81. The essence of this method is as follows: the fighters, being in the air alert zones, are committed to action by the command direction method and destroy the air enemy at the assigned lines as the ground radars detect the air targets.

This method makes it possible to gain the time required for engine starting, takeoff, climb, etc. Owing to this the required early warning distance as compared to that in operation from the "airfield alert" state, with the assigned destruction line being the same, is reduced by a value, calculated by the formula:

$$\Delta D_{warn} = V_{tgt}(t_{dec} + t_{read} + t_{H\ ass} + t_{lev.\ fl} - t_{turn}) + V_{ftr}\ t_{lev.\ fl},$$

where t_{dec} is the time required for taking a decision by the commander to take off;

t_{read} is the time required for the fighter to take off from readiness No. 1;

$t_{H\ ass}$ is the time required for climbing to the air alert zone altitude;

$t_{lev.\ fl}$ is the time required for the level flight to the air alert zone;

t_{turn} is the time required to turn the fighter to face the target.

The zone air alert is organized in the most likely directions and for the time of the expected air enemy raid.

When acting according to this method, the effectiveness much depends on the efficient selection of the air alert zone location.

The location of the air alert zone should ensure:

- destruction of the air target within the minimum time from the moment of its detection by the ground radars;
- possibility of surveillance of the fighters by the radars whose data will assist direction;
- steady radio communication with the fighters.

The location of the air alert zone is determined with respect to the detection line of the ground direction radar with due regard for:

- PPI jammed areas due to ground clutter;
- target flight speed;
- time required for the fighter to turn to meet the enemy.

The distance ($D_{alert\ zone}$) between the centre of the air alert zone and the detection line of the direction radar is calculated by the formula:

$$D_{alert\ zone} = V_{tgt}\, t_{maneuver} - (D_{lnch} + S_{appr} - S_{ftr}),$$

where $t_{maneuver} = t_{straight} + t_{turn} + t_{appr}$;

D_{lnch} is the missile launching range;

S_{appr} is the distance covered by the fighter for the approach time;

S_{ftr} is the distance covered by the fighter from the zone to a point of turn to the target flight course;

$t_{straight}$ is the time of straight flight to the point of turn to the target flight course;

t_{turn} is the time of turn to the target flight course;

t_{appr} is the time of closure on the target to a missile launching range.

The distance between the destruction line and the direction radar detection line is determined by the formula:

$$D_{destr.\ line} = V_{tgt}\, t_{maneuver}.$$

The aircraft acceleration and climb may be performed during the straight flight to the turn initiation point, when making the turn and approaching the target.

To determine the air alert duration time, use is made of the charts (Figs 10 to 12) calculated for the maximum-endurance air alert flight in the zone.

Depending on the air situation, the fighters fly in the air alert zone making a figure eight or box with the two- or three-minute straight legs in the maximum endurance flight conditions. The flight altitude in the air alert zone is selected with regard for ensuring security of air barrage from detecting by the ground radars of the enemy and reliable surveillance of the fighters by the friendly ground radars. In addition, while selecting the air alert altitude, consider the predicted flight altitude of air targets.

3.4. SEMIAUTONOMOUS (INDEPENDENT) SEARCH AND DESTRUCTION OF AIR ENEMY IN ASSIGNED AREA

82. Semiautonomous are the actions in which the fighters are brought into contact with the target according to the assigned program calculated on the basis of the target initial data combined with the independent search of the target by the pilot under no continuous radar field.

The fighter semiautonomous search is used when the radar field has "gaps", i.e., the airspace dead zones. In this case, the information on the air enemy is delivered to the fighter interruptedly, only when the air enemy is within the radar field.

83. The independent search is the actions of the fighter when the enemy air assault means are searched and destroyed within the air alert zone when no information on the target flight parameters is available.

The fighter independent search is used in absence of the radar field, that is, when only partial information on the target flight is available, and the air enemy is searched with the help of the airborne detection facilities and visually within the airspace blind for the ground radars.

84. The essence of the semiautonomous search is based on predicting the air enemy flight parameters after the information on the air enemy stops to flow in.

The initial information on the targets is transmitted to the control post. It may be transmitted by the ground warning radars, aircraft and ships of the radar picket. In addition, the electronic countermeasures taken by the enemy to the friendly ground

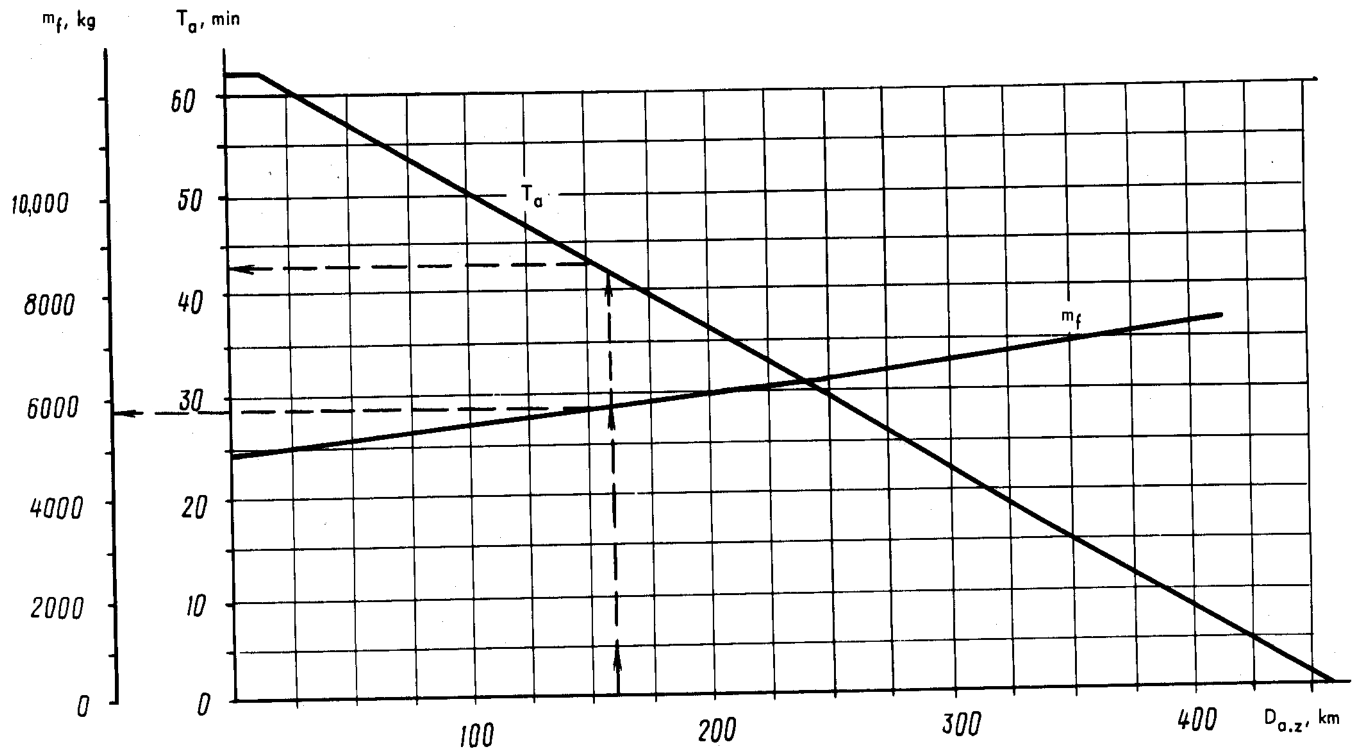


FIG. 10. CURVE FOR DETERMINING AIR ALERT TIME T_a AND FUEL REMAINDER m_f ENSURING CONDUCTANCE OF AIR COMBAT AND RETURN TO LANDING AIRFIELD VERSUS ALERT ZONE DISTANCE $D_{a.z.}$

(alert zone altitude $H_{a.z}$ 3000 m)

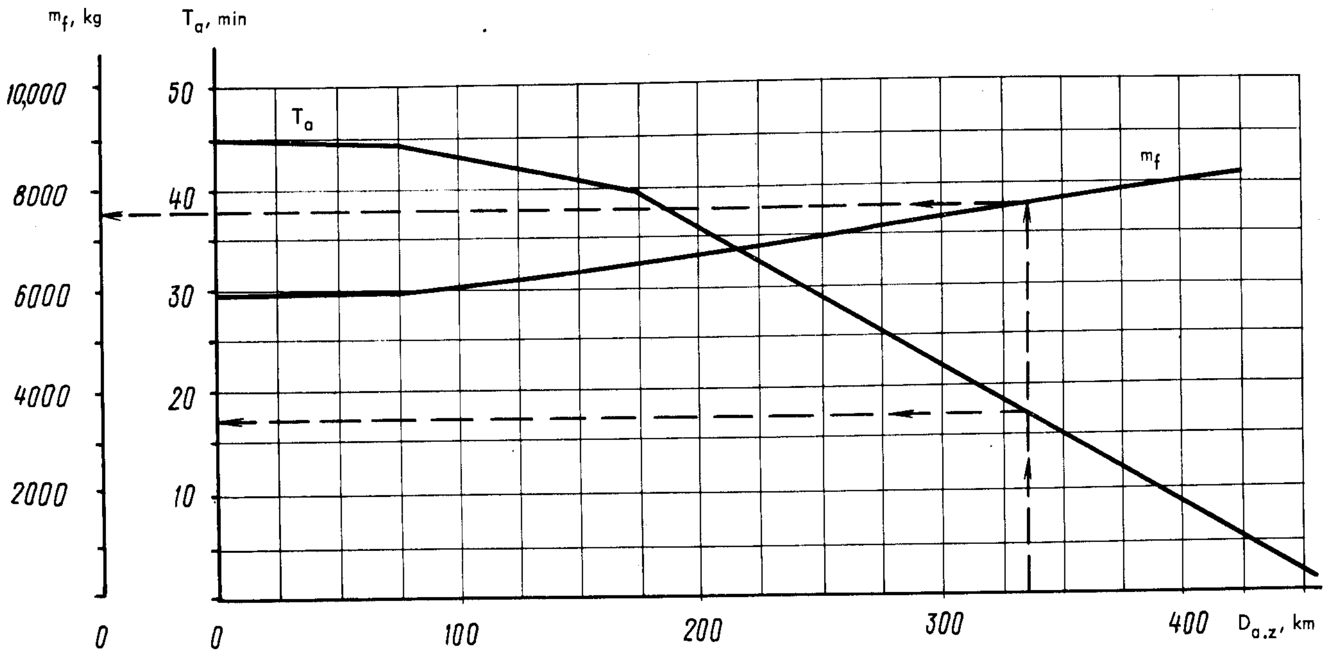


FIG. 11. CURVE FOR DETERMINING AIR ALERT TIME T_a AND FUEL REMAINDER m_f ENSURING CONDUCTANCE OF AIR COMBAT AND RETURN TO LANDING AIRFIELD VERSUS ALERT ZONE DISTANCE $D_{a.z}$

(alert zone altitude $H_{a.z} = 8000$ m, $H_{ref} = 8000$ m)

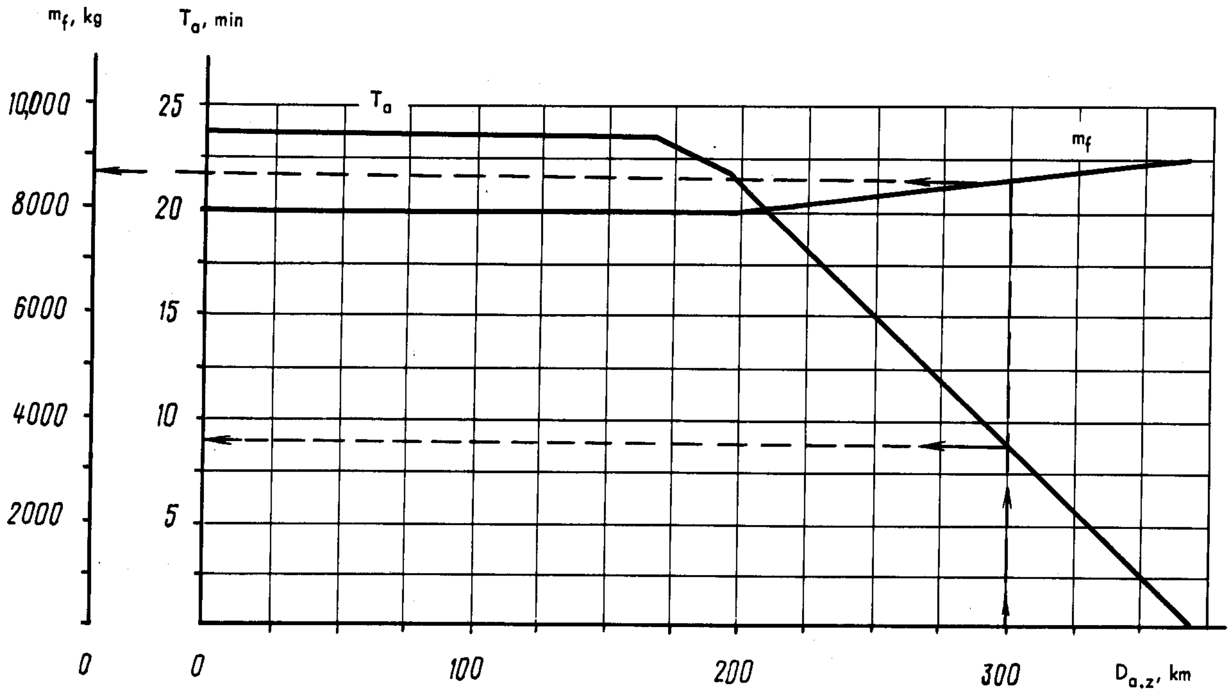


FIG. 12. CURVE FOR DETERMINING AIR ALERT TIME T_a AND FUEL REMAINDER m_f ENSURING CONDUCTANCE OF AIR COMBAT AND RETURN TO LANDING AIRFIELD VERSUS ALERT ZONE DISTANCE $D_{a.z}$

(alert zone altitude $H_{a.z}$ = 8000 m, H_{ref} = 18,000 to 20,000 m) radars and fire neutralization of the radar system can serve as the initial information on the air attack.

On the basis of the intelligence data on the air attack means, the enemy intentions, his combat actions tactics in the direction of attack under consideration, the flight direction of the targets in the area where no information on the enemy is available is supposed. The supposition on the target flight makes it possible to determine the target potential area changing in time.

The searching capabilities of the fighter (group) are determined by the width of the probable target detection zone (2b). This size is limited by two straight lines parallel to the closure speed vector (Fig. 13) and equals to

$$\ell_{det} = t_{det} \cdot V_{clos},$$

where t_{det} is the minimum time required for detection of the target;

V_{clos} is the closure speed.

The minimum time required for detection of the target depends on the airborne radar azimuth scanning area control mode. If the area is aligned with the centre, 10 s is sufficient for detection of the target. If the scanning area is periodically moved to the extreme (left and right) and middle positions, an additional time is required for evaluation of the air situation in each position of the scanning area, so the minimum required time increases up to 15 to 20 s. That is why, when the target is searched, shift the scanning area at a time period of 15 to 20 s. Keeping of the scanning area in one position for the time more than recommended one is not allowed, since a target may be missed in the other scanning sector.

When the search is conducted by shifting the scanning area, the width of the probable target detection zone will be determined by the time of location of the target in the scanning area. When two sectors are scanned alternately, detected will be the targets who stay in the zone for not less than 30 s. When three sectors are scanned alternately, detected will be the targets with the stay time of not less than 45 s.

As the closure speed increases, the time of target stay in the scanning area decreases and, consequently, the scanned area decreases. Besides, the width of the probable target detection zone depends on the target effective echoing area and the operating mode of the airborne radar, that is, on the detection range.

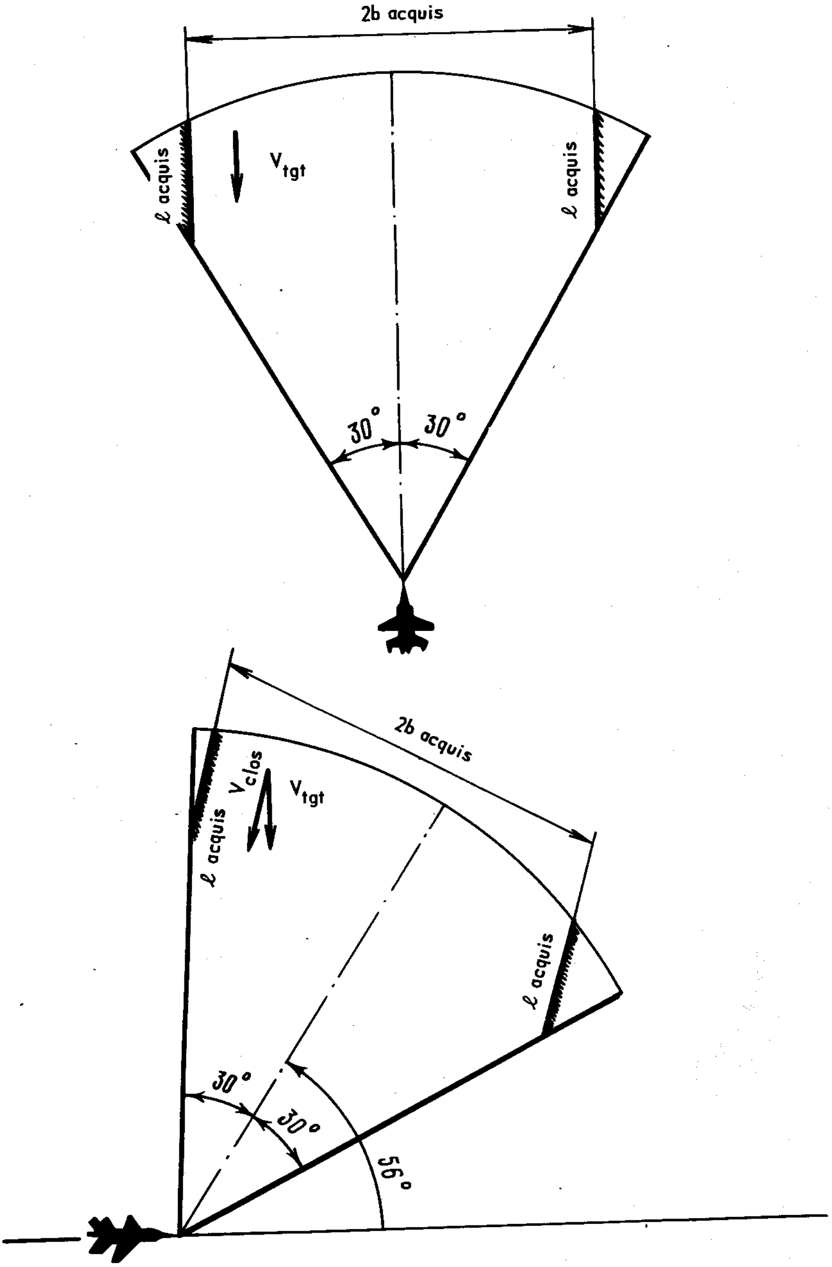


FIG. 13. DETERMINING WIDTH OF AIRSPACE COVERED BY AIRBORNE RADAR

85. In the semiautonomous search, a correct estimation of the air situation is of a great importance. The estimation is based on interchange of the information on the enemy by the pilots of the fighters. The main source of information on the air enemy is the fighter airborne radars, as a rule. The airborne radar helps the pilot to determine the target bearing and range. But the parameters vitally important for cooperation, such as the target flight direction with respect to the fighter, airspeed and altitude of the target, may be determined only indirectly, when the pilot is skilled enough in management of the airborne radar. That is why, it is very important after detection of the target by one of the pilots (either the wingman or the leader) to promptly and timely inform the other pilot on the attitude of the detected target and its maneuvers.

If the pair of fighters attacks the group target, when the first fighter gains contact with the enemy, the second one should continue searching and launch an attack against the other target. In the case, if the pair is engaged in the air combat against a single target, as soon as the first fighter detects the target, the second fighter should maneuver to assume a tactically advantageous position to attack the target.

The leader of the pair is responsible for taking a decision to conduct a combat, to use this or that maneuver. However, it does not deprive the wingman of his initiative.

In the semiautonomous search, the important element of the air combat is determination of the attack trajectory after detection of the target. The МиГ-25ПД (МиГ-25ПДС) fighter can approach the target only by the "pursuit" method from the moment of detection to the moment of lock-on and by the "estimated-lead pursuit" method after lock-on of the target.

The size of the probable target detection zone depends on accuracy of the latest information on the air targets flight coordinates, capabilities of the targets to maneuver in airspeed and course, as well as on the time elapsed from the moment the air enemy crossed the warning line.

The conduction of the semiautonomous search by the МиГ-25ПД (МиГ-25ПДС) fighters is based on the optimum combination of the control from the control post (guidance post) and independent actions of the fighters. The task on bringing the fighters into the target search area should be solved at the control posts and transmitted to the fighter in the form of a program, specifying the flying mode (course, airspeed, altitude, time of the search).

The fighters search the target and fight the air combat independently.

86. The pair of aircraft is a main tactical element when conducting a semiautonomous search on the МиГ-25ПД (МиГ-25ПДС) fighters.

If it is necessary to enlarge the search frontage and to reinforce the striking power for destruction of the air targets, a number of the independent pairs of the fighters may be detailed to fly on the parallel search routes at time intervals. It is not advisable to use a single section combat formation, since it becomes difficult to maneuver in such a combat formation and impossible to establish cooperation between the fighters of the group in the air combat on the basis of the information on the air enemy obtained from the airborne radar.

87. The combat formation of the fighters is selected depending on the search conditions, tactical situation and the stage of flight.

When flying to the search area, the combat formation should ensure easy hold of the assigned flight conditions, free maneuvering of the leader and wingman, minimum time for an independent regrouping of the combat formation for the target search.

In search and air combat, probability of detection and destruction of the air enemy in a wide frontage should be ensured. This may be attained when the fighters fly in a line-abreast or echelon formation.

The parameters of the combat formations are determined mainly by the methods of maintaining the combat formations.

The visual method of maintaining the combat formation allows the pilots to stealthily enter the target search area. It is used only in high-visibility conditions and does not ensure the target detection in a wide frontage. That is why, in the semiautonomous mode, the main way of maintaining the combat formation is a radar contact flight with the aid of the airborne radars.

When making a radar contact flight, at the air target search stage the combat formation parameters are selected so as to ensure the maximum width of the scanning area and at the same time continuously displaying of the leader mark on the integrated display screen.

The expedient position of the leader (commander) in the combat formation is that behind the wingman. In this case, the leader observes the wingman on the integrated display screen and has a possibility to better estimate the air situation and to take a decision on conduction of the combat.

88. The main search method for the МиГ-25ПД (МиГ-25ПДС) fighters is a straight-line search on head-on courses.

When this search method is employed, the fighters are brought onto the target head-on course and search the target in a straight flight with the help of the airborne radar.

The radar operating mode is selected depending on the flight altitude of the fighter and that of the target.

The "pursuit" method is characterized by the fact that at any moment the fighter speed vector is directed to the target. To realize this method, the pilot should keep the target blip on the zero azimuth line after the target is detected.

As the target is locked on, the analog computer continuously calculates the required lead angle. When the larger ring is held on the integrated display screen crosshairs, the fighter speed vector is directed to the missile-to-target collision point and the fighter flies along the estimated-lead pursuit trajectory.

Chapter 4

PILOT'S ACTIONS WHEN EXECUTING COMBAT MISSION

4.1. PILOT'S ACTIONS BEFORE COMBAT FLIGHT

89. Each combat flight includes:
- preparation of the armament system for employment;
- target area approach, acquisition and identification of the target;
- aiming and launching of missiles;
- breaking off from the attack;
- return to the landing airfield.

90. Before executing the combat flight, listen to the aircraft technician's report on the variant of prepared armament and presence of the film in the camera gun.

During the visual inspection of the aircraft, check the variant of prepared armament for compliance with the flight mission, make certain that the missiles are free from damage and the safety pins are available on the launchers.

91. After taking a seat in the cabin, make certain that the firing button trigger is set to the safety position, all the circuit breakers located on the power board, the selector switches located on the control panels of the SAPFIR-25 airborne radar and the heat direction finder are turned off. Check the cabin glass panels and the K-10T collimating sight reflector for cleanliness.

Prepare the cabin in compliance with the directions laid down in the Flight Manual.

Establish the communication over the radio with the control post combat control officer and check the automatic radio link for serviceability by making certain that the course, airspeed and altitude readings correspond to the assigned commands.

4.2. PILOT'S ACTIONS AT GROUND AND AIRBORNE DIRECTION IN AUTOMATIC (DIRECTOR) AND MANUAL AIRCRAFT CONTROL MODES

4.2.1. Pilot's Actions at Ground and Airborne Direction in Automatic (Director) Aircraft Control Modes and at Direction from Ground Automatic Control System

92. The air combat flight may be executed according to one of the programs stored in the automatic flight control system.

After starting the engines, the pilot should:

- set the levelling-off altitude and airspeed values on the airspeed and altitude setter panel versus the selected climbing program;
- set the limit altitude on the radio altimeter;
- turn on the PULL-OFF (УВОД) switch located on the automatic flight control system panel and press the light-button labelled DIRECT (НАВЕД.);
- prepare the C-25 armament control system for operation.

After takeoff and climb to an altitude exceeding the selected limit altitude, set the ILLUM - DUMMY - OFF (ИЗЛ. - ЭКВ. - ВЫКЛ.) selector switch to the DUMMY position and, if required, check the C-25 armament control system with the aid of the built-in test system and select one of the programs loaded into the automatic flight control system.

93. At ground direction, with the "Reheat" command delivered at the takeoff, perform climbing according to the reheat program, and in case of absence of the "Reheat" command, according to the combined or cruising program in the automatic (director) mode (Fig. 14).

94. Enter the climb program at an altitude of not less than 300 to 500 m and an airspeed of not less than 600 to 650 km/h, for which purpose, without descending, set the command pointers within the small circle of the flight director indicator and the position bars, to a position close to the zero one.

This done, depending on the selected program, climb to the assigned altitude and accelerate the aircraft up to the programmed airspeed in the automatic (director) mode; in so doing, make certain that the 5У15К-11 airborne direction and target designation equipment functions normally.

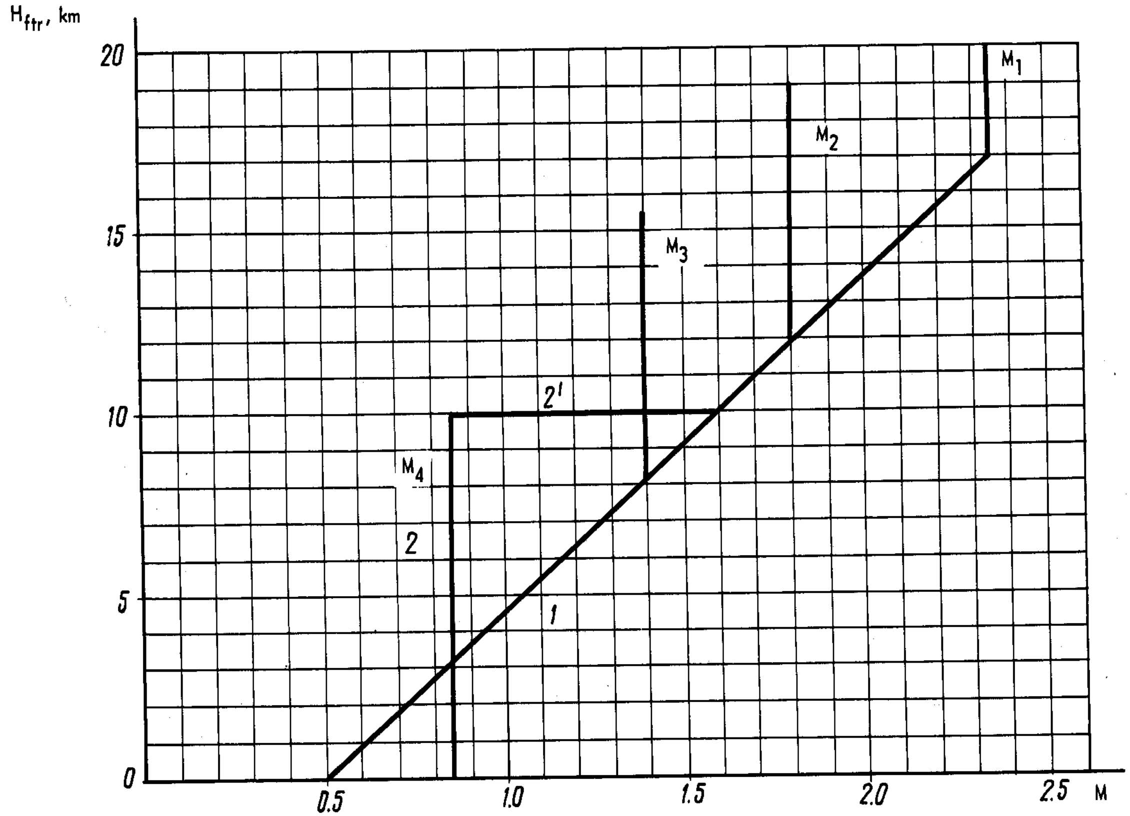


FIG. 14. CLIMBING AND DESCENDING IN AUTOMATIC (DIRECTOR) CONTROL MODE ACCORDING TO AFCS PROGRAM
1 – reheat program for war time; 2 – 2' – reheat program for peoce time and combined program; 2 – cruising program

If the commands are not delivered from the ground automatic control system, perform the flight either in the manual control mode or in the angular position stabilization mode.

On the "Fulfill commands" instruction, accomplish the piloting by the direction commands delivered from the control post (direction post) with the use of the 5У15К-11 airborne direction and target designation equipment.

95. For climbing in the automatic (director) control mode, proceed as follows:

- when flying according to the reheat program of the war time, set levelling-off altitude ($H_{lvl-off}$) equalling 29.9 km and the assigned airspeed on the airspeed and altitude setter. Climb at the full reheat power setting;

- when flying according to the reheat program of the peace time, set the levelling-off altitude ($H_{lvl-off}$) equalling 29.9 km on the airspeed and altitude setter and place wafer selector switch M_{set} in the H10 position. Climb to an altitude of 10,000 m at the full reheat power setting.

96. The climb at the full reheat power in the automatic (director) mode is stable provided the pilot properly enters the climb program manually. For this purpose, before the longitudinal channel command pointer passes from below through the zero position, increase the pitch angle with the further holding of the command pointer in the zero position till the climb program is completely entered (till the stable zeroing of the longitudinal channel position bar). On completion of the climb program entry, trim out the control stick by the trim mechanisms, press the AUTO CONTROL (АВТ. УПР.) light-button on the automatic flight control system panel and release the control stick. When the aircraft correctly executes the subsonic program at the full reheat power setting during the automatic climb, the flight path angle will be not in excess of 30°.

Note. Selection of the automatic control when the longitudinal channel command pointer reaches the zero position from below while accelerating the aircraft in the level flight at an altitude of about 1000 m results in the initial increase of the present Mach number ($M_{present}$) with respect to the selected Mach number (M_{assign}) equalling 0.85, which in its turn leads to increase in the pitch angle up to 40° and decrease in the Mach number up to 0.6. In the process of climbing, the damped oscillations with respect to the Mach number with an amplitude of ± 0.15M appear up to an altitude of 5000 to 7000 m.

97. When reaching an altitude of 10,000 m, the SEL ALT LVL-OFF (СХОД $H_{ЗАД}$) lamp lights up and the "Selected altitude levelling-off" voice information is delivered to the earphones.

In response to this command, throttle the engines so as to gradually reach an altitude of 10,000 m.

Note. When the aircraft control director mode is selected, cut in the damper with the aid of the DAMP (ДЕМПФ.) light-button located on the automatic flight control system panel after gaining an altitude of 10,000 m.

While accelerating the aircraft, at an altitude of 10,000 m set the assigned airspeed value on the airspeed and altitude setter:

- M_3 = 1.4 at the airspeed corresponding to $M \approx 1.3$;
- M_2 = 1.8 or M_1 = 2.35 at the airspeed corresponding to $M \approx 1.4$.

CAUTION. WHEN ACCELERATING THE AIRCRAFT TO ENTER THE BASIC PROGRAM ($M_{ENTRY} \approx 1.58$), IT IS NECESSARY TO CHECK THE INDICATED AIRSPEED, AVOIDING ITS INCREASE OVER 1150 km/h. IF THE AIRSPEED EXCEEDS THE SPECIFIED VALUE, BRING THE AIRCRAFT INTO CLIMBING BEFORE ENTRY INTO THE PROGRAM.

98. When flying according to the combined program, proceed as follows:

- set $H_{lvl-off}$ = 29.9 km on the airspeed and altitude setter and place wafer switch $M_{assigned}$ to the H10 position;
- perform the takeoff at the full reheat power setting and switch off the afterburner as soon as an airspeed of 600 km/h is reached;
- enter the automatic flight control program and proceed to climbing, with the engines running at the maximum power setting;
- in response to the command delivered from the ground control (direction) post, turn on the full reheat, climb to an altitude of 10,000 m and proceed flying in the same way as according to the reheat program of the peace time.

99. When flying according to the cruising program, proceed as follows:

- set $H_{lvl-off}$ = 29.9 km and $M_{assigned}$ = 0.85 on the airspeed and altitude setter;
- perform the takeoff at the full reheat power setting and, when an airspeed of 600 km/h is reached, switch off the afterburner;

- enter the automatic flight control program and perform climbing, with the engines running at the maximum power setting.

100. When climbing in the director mode, hold the command pointers within the circle. When the discrete commands ($<$ or $>$) are delivered, perform the turn only when the vertical pointer of the flight director indicator starts deflecting. Check the variation of the assigned course by reference to the combined course indicator.

101. With the automatic control mode selected, check the flight director indicator commands for being properly followed up by the aircraft.

When directing the aircraft at the altitudes exceeding 1500 m, accomplish the turn with a roll of up to 60°, and when directing the aircraft at the altitudes less than 1500 m, accomplish the turn with a roll of up to 30°.

102. When flying the aircraft carrying the drop fuel tank, climb in the automatic, director or manual control mode, observing the effective flight limitations relating to the flight with the drop fuel tank.

Jettison the drop fuel tank in the manual control mode. After jettisoning the drop fuel tank, proceed flying in the automatic (director) control mode.

When approaching the attack altitude, the SEL ALT LVL-OFF (СХОД $H_{ЗАД}$) lamp lights up and the "Selected altitude levelling-off" ("Сход на высоту") voice information is delivered.

When it is necessary to select the attack altitude other than the programmed one (for example, for executing the rear-cone low or forward-cone overhead attack), depending on the flight altitude of the target displayed on the УВО-М1 indicator, it is necessary to set the levelling-off altitude on the airspeed and altitude setter and use the ΔH selector switch to set the step-up (step-down) separation, selected from the conditions of the attack, with the subsequent climb in the automatic or director mode with interception of the attack altitude.

103. In case of transition to the greater Mach numbers, accelerate the aircraft up to $M_{assigned}$ while descending, with both engines operating at the full reheat power setting.

104. On reaching the attack altitude, check the automatic switching-on of the airborne radar for illumination within the ranges of:

- 80 to 90 km when launching the forward-cone attack against the high-altitude high-speed targets;

- 40 to 50 km when launching the forward-cone attack against the subsonic speed targets;
- 30 to 35 km when launching the rear-cone attack against the high and medium-altitude targets;
- 15 to 20 km when launching the rear-cone attack against the low-altitude targets.

In attacking the target flying with the step-up separation over 3000 m with respect to the fighter, the "Preliminary zoom" command is delivered (index Z (zoom) is displayed before the target is locked on by the airborner radar). Upon displaying the Z index, when the automatic control mode is selected, check the aircraft transition to climbing at a pitch angle of 5°. When controlling the aircraft in the director mode, execute the preliminary zoom, keeping the small circle in the centre of the electronic crosshairs.

105. After acquisition and identification of the target, lock-on the latter. With the automatic control mode selected, after the target has been locked on, check for automatic correction of the direction errors by the aircraft. When the director control mode is selected, perform a maneuver to eliminate the direction errors, keeping the small circle within the centre of the electronic crosshairs. While approaching the target, check the aiming errors by reference to the flight director indicator deviation bars.

In delivering the command for executing the aiming zoom (lighting-up of the Z index), check to see that the aircraft enters automatically the climbing (descending) altitude. When flying in the director control mode, execute the aiming zoom, keeping the circle within the electronic crosshairs centre.

On the "Reheat" command, timely switch on the engine afterburners, avoiding the airspeed drop below the maneuvering one.

To preclude the airspeed drop below the maneuvering one, launch an attack in the automatic (director) control mode, when flying at the altitudes ranging from 3000 to 7000 m, at a speed of not less than 750 km/h and with the step-up separation of the target relative to the fighter being not more than 2500 m.

On the aircraft furnished with the САУ-155ПДБ system, launch the missiles within the in-range zone and in response to the "Breakaway" command, check the fighter for the automatic breaking off from the attack with its subsequent levelling.

When flying at the Mach numbers equal to 2.5 and more, prior to launching the missiles, switch off the automatic flight control system, launch the missiles and break off from the attack in the director control mode.

On the aircraft furnished with the САУ-155П1ДБ system, the automatic flight control system is disconnected at the moment the firing button is pressed (the AUTO CONTROL (АВТ. УПР.) light-button extinguishes).

After launching the missiles, break off from the attack in the director control mode.

106. The attack against the target in the automatic control mode terminates in levelling the aircraft after breaking off from the attack. At the altitudes above 2500 m, break off from the attack with the roll of up to 70°, and at the altitudes below 1500 m, with the roll of up to 30°.

After cancellation of the "Breakaway" command, check to see that the DIRECT (НАВЕД.) light-button becomes dead, the LEVELLING ON (ВКЛ. ПРИВ. ГОРИЗ.) light-button lights up and the command bars assume the position within the circle and become immovable.

When the director control mode is selected, after cancellation of the "Breakaway" command, press the MODE RESET (СБРОС РЕЖ.) button located on the automatic flight control system control panel and change over to the aircraft manual control.

107. After accomplishing the attack against the high-altitude high-speed targets, switch off the DIRECTION mode and decelerate the aircraft to an airspeed of 600 km/h with a simultaneous turn at a roll of 40 to 45° towards the landing airfield, with the engines running at the MAXIMUM (МАКСИМАЛ) power setting. After performing the turn, execute the straight-in let-down to the cruising altitude at an airspeed of 600 km/h, with the engines running at the IDLE (МАЛЫЙ ГАЗ) power setting.

The basic flying regime in returning to the airfield is the flight at the cruising altitude of 9000 to 10,000 m with the constant Mach number equal to 0.85.

For performing the flight at the cruising altitude (9000 to 10,000 m) in the automatic or director control mode, select the maximum engine power setting, set the Mach number equal to 0.85 on the airspeed and altitude setter and enter the AFCS program.

When flying for the air combat at the altitudes below 9000 m, the flight altitude in return to the airfield depends on the distance to the airfield and the fuel remainder in each particular case.

4.2.2. Pilot's Actions at Ground and Airborne Direction during Flight in Attitude Stabilization Mode and at PPR-Assisted Voice Direction

108. Prior to taking off, set the SELECTED COURSE: AUTO - MANUAL (КУРС ЗАДАН. АВТОМ. - РУЧНОЙ) selector switch to the MANUAL (РУЧНОЙ) position. After takeoff, set the fighter flight altitude assigned by the ground control (direction) post on the airspeed and altitude setter. Use the setting knob on the course setter to set the course assigned by the ground control (direction) post on the НПП combined course indicator. Flying the aircraft in the manual control mode, intercept the assigned course.

109. After interception of the assigned course, press the DIRECT (НАВЕД.) light-button. Zero the command pointers, use the trim mechanisms to trim out the control stick, press the AUTO CONTROL (АВТ. УПР.) light-button and release the aircraft control stick.

110. When the flight course is changed by the ground control (direction) post, set the new course value by means of the setting knob of the course setter on the combined course indicator. When the course is varied by the setting knob by more than 20°, the aircraft is automatically turned to the course assigned by the setting knob of the course setter at a roll of 60°. If the course is varied by the setting knob by less than 20°, the aircraft is automatically turned to the course assigned by the setting knob of the course setter at a roll of 45°.

The flight altitude is varied by setting the new altitude value on the airspeed and altitude setter.

On the command of the combat control officer, cut in the airborne radar for illumination by setting the ILLUM - DUMMY - OFF (ИЗЛ. - ЭКВ. - ВЫКЛ.) selector switch to the ILLUM position.

After locking on the target, the pilot's actions at the airborne direction are similar to those performed during the direction with the aid of the ground automatic control system.

4.2.3. Pilot's Actions at Ground and Airborne Direction in Aircraft Manual Control Mode

111. In the manual control mode, perform climbing according to the climbing pattern given in Fig. 15.

When flying according to the reheat program specified for the war time, it is necessary to:

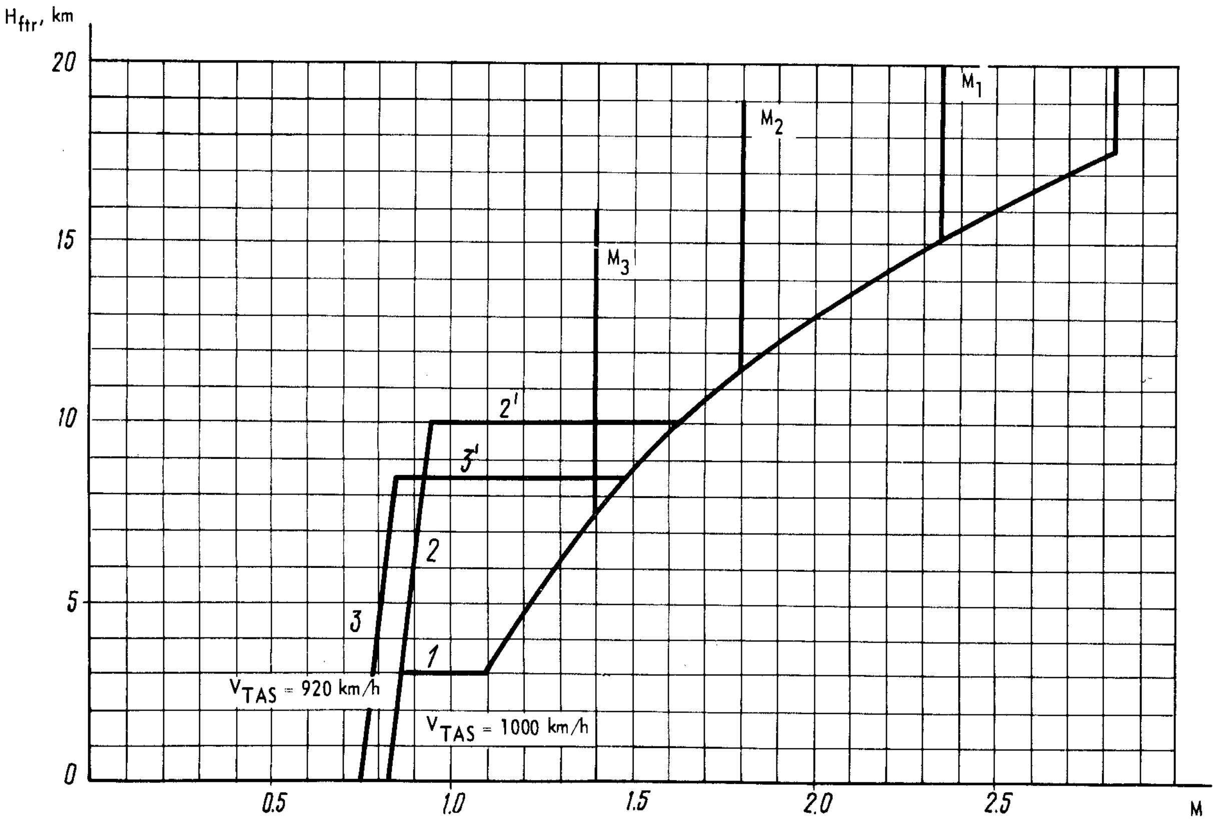


FIG. 15. CLIMBING AND DESCENDING IN MANUAL CONTROL MODE

1 – reheat program for war time; 2 – 2' – reheat program for peace time; 3 – 3' – combined program; 3 – cruising program

- climb to an altitude of 3000 m at a true airspeed of 1000 km/h;

- accelerate the aircraft to an indicated airspeed of 1150 km/h at an altitude of 3000 m;

- perform climbing until the assigned true airspeed (Mach number) is gained at V_{ind} = 1150 km/h and proceed flying at the assigned true airspeed.

When flying according to the reheat program specified for the peace time, it is necessary to:

- climb to an altitude of 10,000 m at a true airspeed of 1000 km/h;

- accelerate the aircraft to an indicated airspeed of 1150 km/h at an altitude of 10,000 m and then proceed climbing according to the war-time reheat program.

When flying according to the combined program, proceed as follows:

- perform the takeoff at the full reheat power setting and, when an airspeed of 600 km/h is reached, switch off the afterburners;

- climb to the cruising altitude at a true airspeed of 900 to 920 km/h with the engines running at the MAXIMUM (МАКСИМАЛ) power setting and then execute the cruising climb flight;

- when changing over to the supersonic airspeed at the altitudes below 11,000 m switch on the full reheat power by the command delivered from the ground control (direction) post and accelerate the aircraft in the level flight to an indicated airspeed of 1150 km/h (when changing over to the supersonic airspeed at an altitude over 11,000 m, it is necessary to climb to this altitude at V_{TAS} = 1000 km/h and accelerate the aircraft till an indicated airspeed of 1150 km/h is gained) and then proceed climbing according to the reheat program profile.

When flying according to the cruising program, perform climbing as stated for the combined program, with the engines running at the maximum power setting.

112. When the programmed airspeed (M_N) is gained, execute climbing and continue to perform the cruising climb flight.

Descend to the selected altitude in the manual control mode, maintaining the descent vertical speeds in compliance with the data given in Table 14.

Table 14

H, m	20,000 to 9000	9000 to 2500	2500 to 300
V_y, m/s	100 to 200	70 to 80	15 to 30

Execute transition to descent and beginning of descent at Mach numbers equal to 1.4, 1.8, 2.35, with the engines running at the MAXIMUM (МАКСИМАЛ) power setting. On reaching a vertical speed of 100 to 120 m/s, change over the engines to the minimum reheat power setting.

When flying at an indicated airspeed of 1150 km/h, execute an entry into descent and beginning of descent with the engines running at the maximum power setting. On reaching a vertical speed of 100 to 120 m/s, switch on the minimum reheat power of one engine (when flying at the altitudes above 9000 m) or of two engines (when flying at the altitudes ranging from 5000 to 9000 m).

When flying at the Mach number equal to 0.85, execute the entry into descent and beginning of descent with the engines running at the idle power setting. On reaching a vertical speed of 70 to 80 m/s, set the maximum power of one engine (when flying at the altitudes over 3000 m) or of two engines (when flying at the altitudes of 800 to 3000 m).

When descending, maintain the Mach numbers to the altitudes of at least:

- 15,000 m for the Mach number equal to 2.35;
- 11,500 m for the Mach number equal to 1.8;
- 7500 m for the Mach number equal to 1.4;
- 3000 m for an indicated airspeed equal to 1150 km/h;
- 300 m for the Mach number equal to 0.85.

113. In response to the command delivered from the ground control (direction) post, set the ILLUM - DUMMY - OFF (ИЗЛ. - ЭКВ. - ВЫКЛ.) selector switch to the ILLUM position.

When the "Preliminary zoom" command is delivered, bring the aircraft into a climb with a pitch angle of 5°. After locking on the target, fly the aircraft by reference to the aiming circle (the large circle), keeping the latter on the electronic crosshairs. Launch the missiles and, as soon as the "Breakaway" command is received, break off from the attack.

4.3. MISSILE LAUNCHING CONDITIONS

114. Launch the P-40Д missiles throughout the entire range of the aircraft flight altitudes at the positive vertical g-loads from 0.2 to 3.0g and the true airspeed of at least 700 km/h. While launching the missiles, the aircraft slipping should not exceed 0.5 of the ball diameter by reference to the slip indicator.

<u>CAUTION</u>. WHEN LAUNCHING THE MISSILES AT THE MACH NUMBER EXCEEDING 2.5, WITH THE "DAMPING" ("ДЕМПФИРОВАНИЕ") MODE SELECTED, THIS MODE IS NOT SWITCHED OFF BY THE KNOB LOCATED ON THE CONTROL STICK. THE ABOVE-MENTIONED MODE CAN BE SWITCHED OFF ONLY AFTER FADEOUT OF THE "BREAKAWAY" ("ОТВ.") SIGNAL LAMP OR AT THE MACH NUMBER LESS THAN 2.5.

115. The P-60 missiles may be launched throughout the entire range of the aircraft flight altitudes at the indicated airspeed below 1200 km/h and the Mach numbers less than 2.35, with the positive vertical g-loads not exceeding 4g .

4.4. PILOT'S ACTIONS AT VARIOUS STAGES OF AIR COMBAT WITH USE OF SAPFIR-25 AIRBORNE RADAR

116. The SAPFIR-25 airborne radar is automatically cut in for illumination when direction is carried out with the aid of the ground automatic control system.

With the 5У15К-11 equipment operating, the airborne radar is cut in for illumination at the following target ranges:

- 36 km in the rear-cone attack;
- 60 km in the forward-cone attack and at the fighter flight altitude below 8000 m;
- 100 km in the forward-cone attack and at the fighter flight altitude over 8000 m.

Depending on the tactical situation, the combat control officer may manually deliver the command to cut in the radar for illumination at any distance to the target. After cutting in the radar for illumination the ILLUM (ИЗЛУЧ.) lamp comes on. In case the command to cut in the radar for illumination fails to pass from the 5У15К-11 equipment, cut in the radar for illumination manually by the command delivered from the ground control (direction) post, for which purpose set the ILLUM - DUMMY - OFF (ИЗЛ. - ЭКВ. - ВЫКЛ.) selector switch to the ILLUM position.

117. When attacking the target into the forward hemisphere, with the step-up separation of the target relative to the fighter exceeding 3000 m, the "Preliminary zoom" command is delivered (index Z is displayed on the indicator screen framing) before the target is locked on. In response to this command, check to see that the aircraft proceeds to climbing with a pitch angle of 5^{o} in the automatic aircraft control mode.

In the manual or director control mode, change over the aircraft to climbing with a pitch angle of 5^{o} after lighting-up of index Z.

118. After cutting in the airborne radar for illumination, estimate the correctness of the azimuth and elevation search zone automatic control. The position of the search zone in azimuth ($\pm 20^{o}$) should correspond to the target fix.

Estimate the position of the area of search in elevation by correspondence of the range delivered by the 5Я15К-11 equipment to the actual target range, maintaining the step-up (step-down) separation of the target relative to the fighter, set by the ΔH selector switch.

If the area of search in azimuth and elevation does not correspond to the actual fix of the target, set the DIRECTION: AUTO - MANUAL (НАВЕД. АВТ. - РУЧН.) selector switch to the MANUAL position and change over to the manual control of the search area with the aid of the direction control knob.

119. After acquisition of the target by maneuvering the fighter or by use of the ΔH selector switch, obtain coincidence of the moment of appearance of the target blip with display of line 2 or 3 on the indicator screen.

Identify the target. With the INTERROGATION (ЗАПРОС) button pressed, the identification mark similar to the target blip appears over the blip of the friendly target.

120. Lock on the target by pressing the LOCK-ON (ЗАХВАТ) button. If the target is beyond the lock-on zone in range (9 km), press the direction control knob before pressing the LOCK-ON button.

The AUTOMATIC RANGE INPUT (ARI) signal lamp extinguishes on the indicator screen framing and the gates defining the lock-on boundaries appear thereon. Shifting the direction control knob forward or backward, displace the gates so that the selected target is located between them and then press the LOCK-ON button.

Note. The maximum range of the lock-on zone displacement in the automatic and manual displacement amounts to 80 km, therefore the maximum range of the target lock-on cannot be in excess of 80 km.

121. After locking on the target the screen display is automatically changed over to the aiming mode.

The indicator screen images when the airborne radar operates in the various modes are illustrated in Figs 16 to 19.

122. Turn on the MASTER ON (ГЛАВН. ВКЛ.) switch. When approaching the target at a distance of beginning of the"Zoom" command execution, the Z index is displayed on the indicator screen framing and the aiming circle jumps up (down).

When the automatic control mode is selected, check to see that the aircraft executes the aiming zoom.

When controlling the aircraft in the director or manual control mode, execute the aiming zoom.

When the automatic (director) control mode is selected, determine the aiming errors by reference to the flight director indicator deviation bars. With the manual control mode selected, determine the aiming errors by reference to the aiming circle.

123. Launch the missiles singly or in trains of two missiles when the range mark reaches the maximum permissible launching range and when the 1, 2, 3, 4, LP (ПР) signals are delivered. After launching the radar homing missiles, illuminate the target till it is destructed. On reception of the "Breakaway" command, break off from the attack.

124. For launching missiles P-60 or P-60M, change over to the manual control mode, set the OUTBD - AUTO - INBD (ВНЕШН. - АВТОМ. ВНУТР.) selector switch to the OUTBD position. The indicator screen will display the large circle whose coordinates (azimuth-elevation) coincide with the target coordinates. The gyro horizon line is zeroed in pitch. When the distance to the target is less than 15 km, the "fin" blip appears on the indicator screen. When the range mark reaches the maximum permissible launching range, the 1, 4, LP signals are displayed and the audible signal is heard in the earphones, launch the missiles singly or in trains of two missiles. On reception of the "Breakaway" command, break off from the attack.

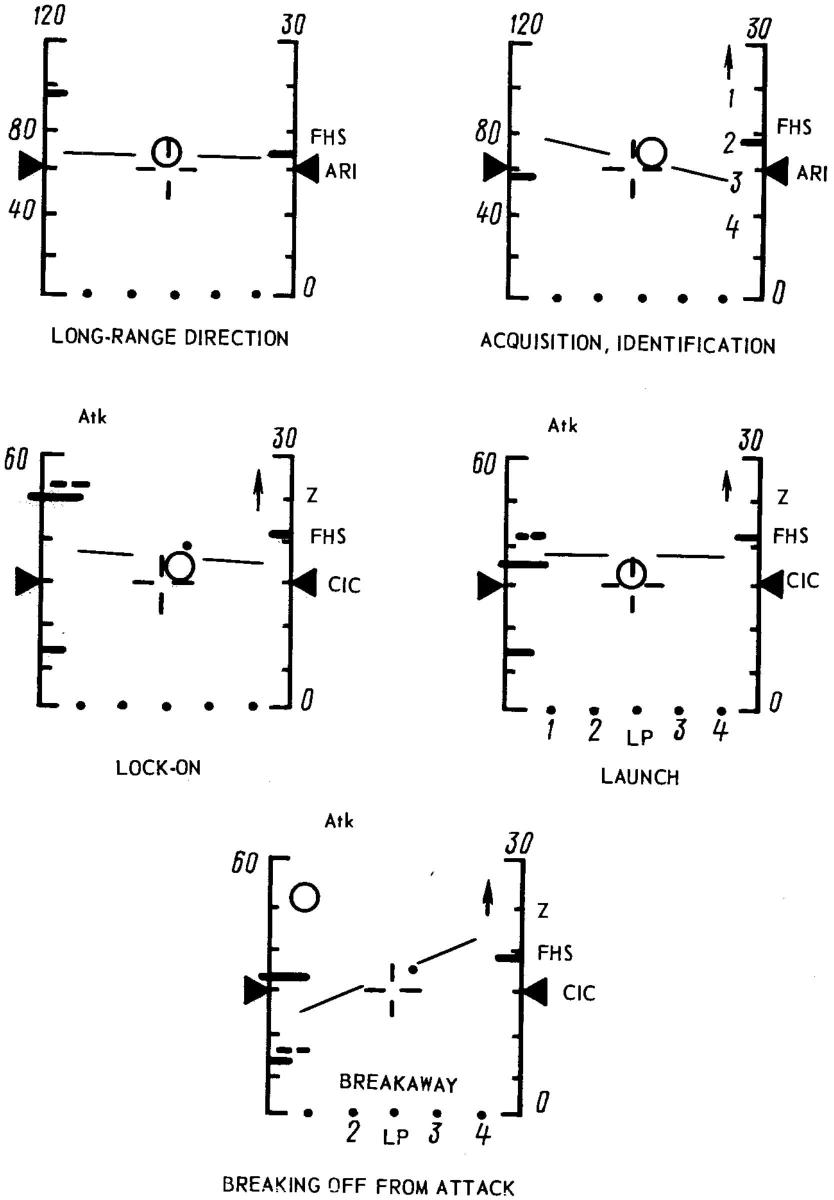


FIG. 16. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF AIRBORNE RADAR IN "HMA" MODE
(forward-cone attack, direction of fighter by ground automatic control system, automatic (director) aircraft control mode)

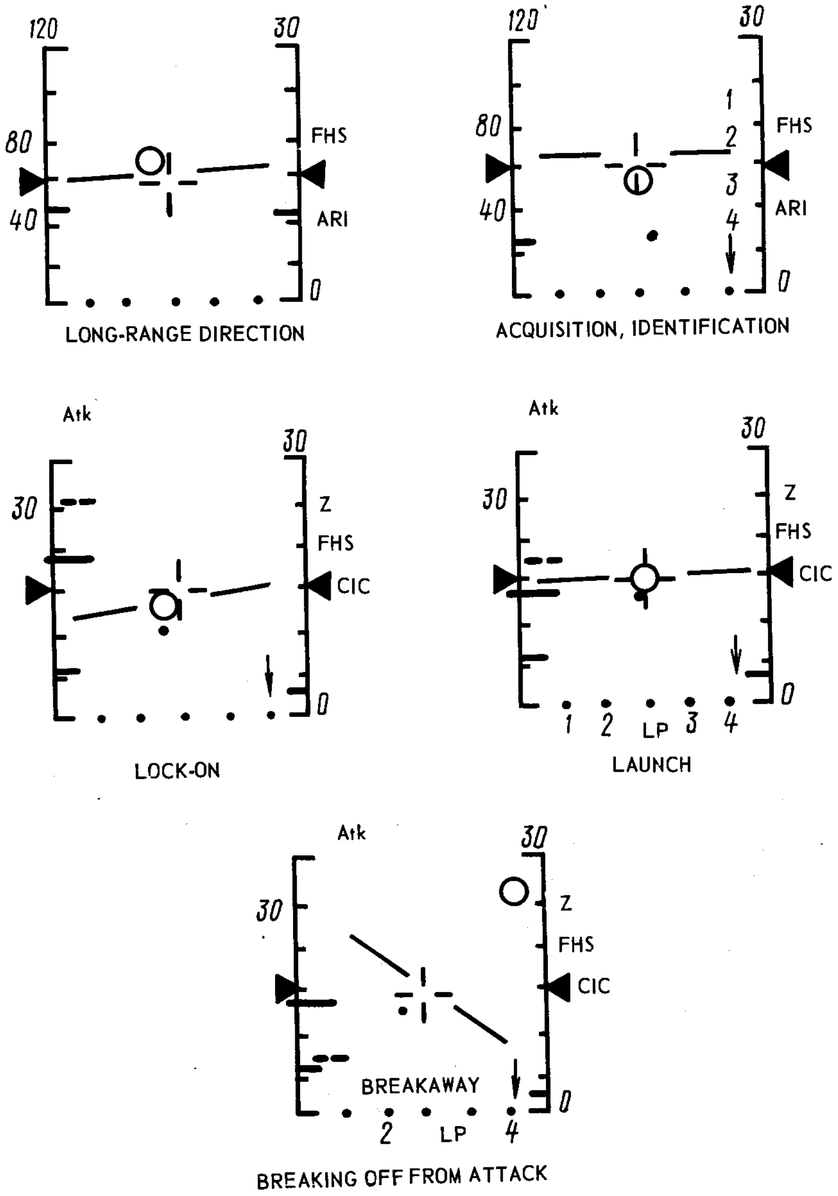


FIG. 17. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF AIRBORNE RADAR IN "HMA–ΔH" MODE
(forward-cone attack, direction of fighter by ground automatic control system, aircraft automatic control mode)

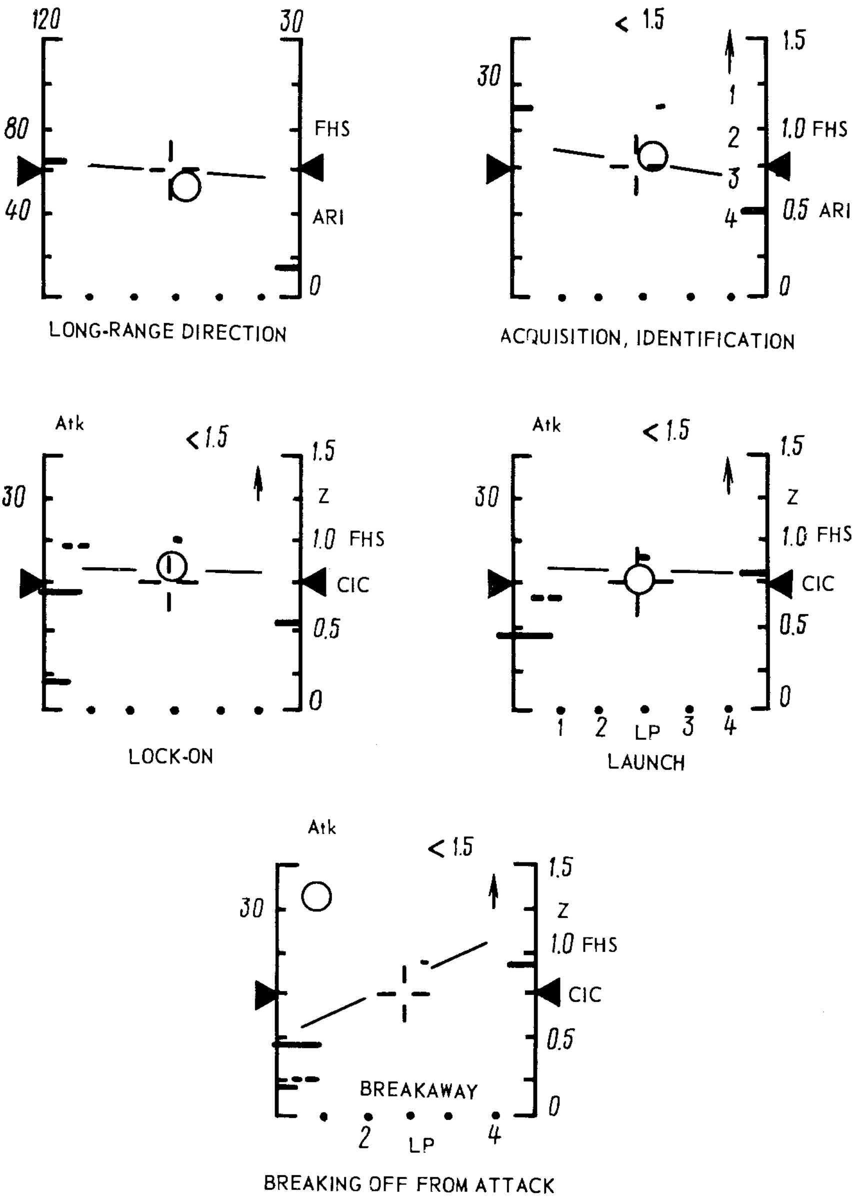


FIG. 18. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF AIRBORNE RADAR IN "MLA" MODE
(forward-cone attack, direction of fighter by ground automatic control system, automatic (director) aircraft control mode)

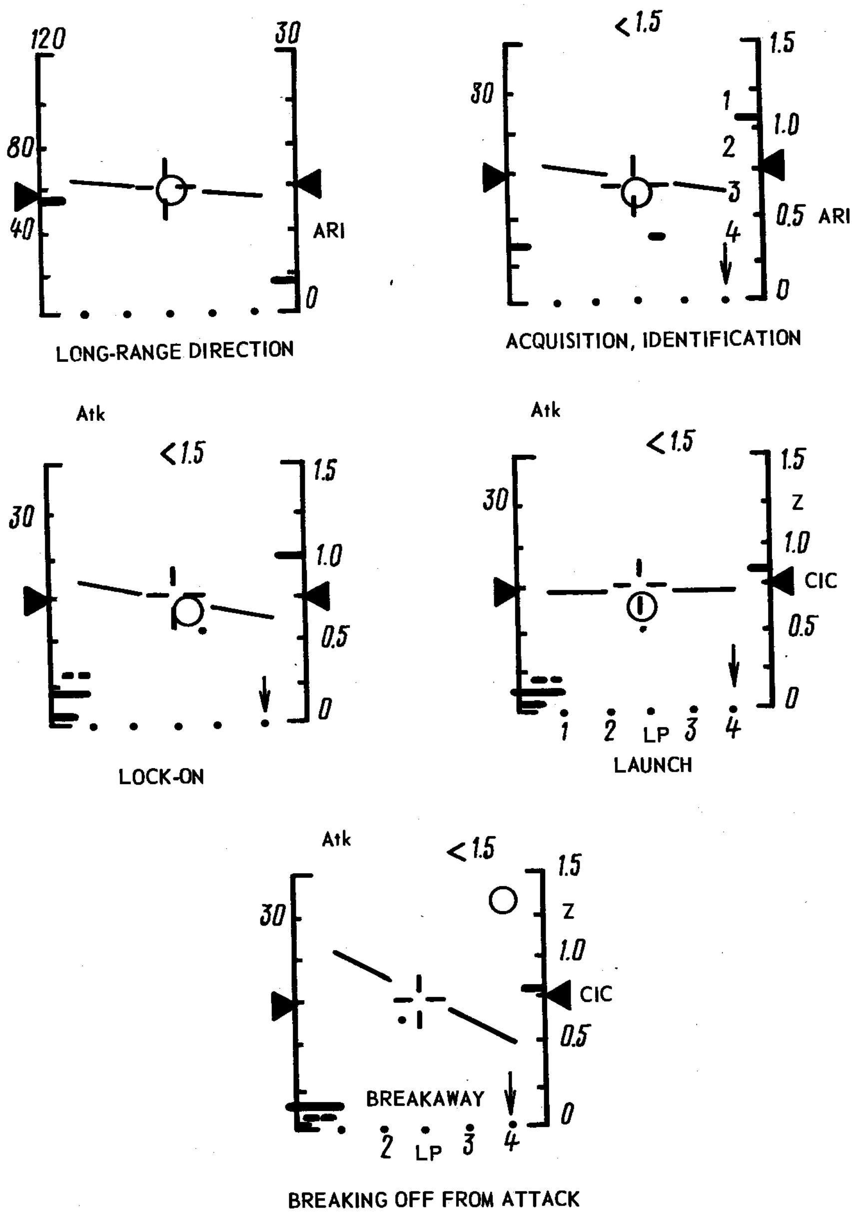


FIG. 19. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF AIRBORNE RADAR IN "LA" MODE
(rear-cone attack, direction of fighter by ground automatic control system, automatic (director) aircraft control mode)

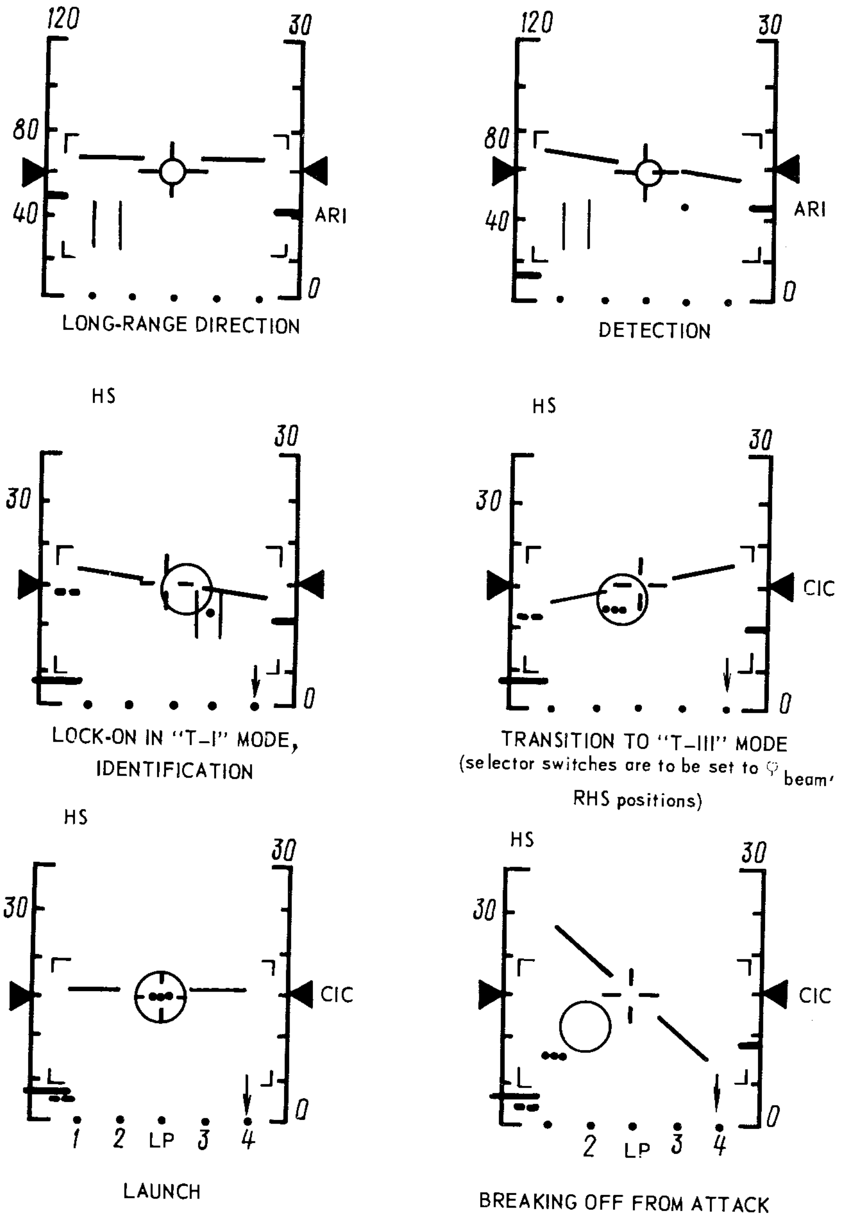


FIG. 20. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF HEAT DIRECTION FINDER IN "T–I" MODE WITH TRANSITION TO "T–III" MODE

(rear-cone attack, direction of fighter by ground automotic control system, airborne rodar operates in "quasi-scanning" mode)

4.5. Pilot's Actions at Various Stages of Air Combat with Use of Heat Direction Finder

125. The attack against the air target with use of the heat direction finder is executed for ensuring the surprise of the attack and increasing the noise immunity against the radar countermeasures as well as in case of failure of the airborne radar.

126. Bringing of the fighter to the range of the target probable acquisition by the heat direction finder is effected with the aid of the 5У15K-11 equipment or by the command (voice) delivered from the ground control (direction) post. The target acquisition range depends on the type of the target, engine power setting, target aspect, flight altitude, transparency of the atmosphere.

The attack against the air target with use of the heat direction finder practically can be launched in the simple and complicated noise background conditions, irrespective of the time of the day and season of the year, in absence of clouds between the fighter and target.

In the simple noise background conditions the T-I or T-III mode of operation of the heat direction finder is employed. For detailing the situation in the complicated conditions, when the target cannot be discriminated against the noise background or if there is a certain doubt concerning the quantity of the targets, the T-II mode of operation of the heat direction finder is used.

127. For using the heat direction finder, it is necessary to set the airborne radar and armament system controls to the same position as in operation of the airborne radar, depending on the aircraft direction method and its control mode. Place the SYST (CИCT.) selector switch to the T-I position.

At the stage of the long-range direction the indicator screen display is the same as during operation of the airborne radar before the radar is cut in for illumination with additional display of the boundary of the acquisition zone and gates of the heat direction finder (Fig. 20).

Before the target is locked on, the aircraft is controlled in the automatic (director) or manual control mode.

Due to limited scanning of the heat direction finder in elevation (4° upward and 9° downward), it is necessary to be well aware of the maximum step-up (step-down) separation of the target relative to the fighter depending on the distance to the target at which the target will be in the filed of scanning of the heat direction finder (Table 15).

Table 15

Target range, km	Maximum step-down separation of fighter relative to target, km	Maximum step-up separation of fighter relative to target, km
100	7	16
90	6	14
80	6	13
70	5	11
60	4	9
50	3.5	8
40	3	6
30	2	5
20	1.4	3
10	0.7	1.5

After interception of the attack altitude by the fighter and detection of the target blip on the indicator screen, switch off the automatic control system, change over to the manual control of the aircraft, set the ILLUM - DUMMY - OFF (ИЗЛ. - ЭКВ. - ВЫКЛ.) selector switch to the ILLUM position, use the direction control knob to impose the gates of the heat direction finder on the target and lock on the target by pressing the LOCK-ON (ЗАХВАТ) button located on the aircraft control stick.

After locking on the target, the HS (heat seeking) signal, the maximum permissible launching range mark ($D_{max. perm}$) and the quasi-scanning mark of the target range are displayed on the indicator screen.

During operation of the heat direction finder the maximum permissible launching range mark is fixed (it does not depend on the closing speed) and is calculated from the condition that the fighter-to-target closing speed in the rear-cone attack is equal to 100 m/s.

<u>CAUTION.</u> TO OBTAIN THE QUASI-SCANNING RANGE MARK, AT THE FIGHTER FLIGHT ALTITUDE BELOW 1500 m AND WHEN ATTACKING THE AIR TARGET AGAINST THE GROUND CLUTTER BACKGROUND, AFTER LOCKING ON THE TARGET BY THE HEAT DIRECTION FINDER, USE THE DIRECTION CONTROL KNOB TO SET THE RANGE FINDER LOCK-ON ZONE CENTRE MARK TO A RANGE LESS THAN 12 km.

128. On appearance of the quasi-scanning range mark, identify the target, for which purpose press the INTERROGATION (ЗАПРОС)

button located on the direction control knob. If the target proves to be friendly, the identification mark will appear over the quasi-scanning range mark. Turn on the MASTER ON switch.

129. If it is necessary to discriminate the target from the group of targets or during operation of the heat direction finder in the complicated noise background situation, employ the T-II mode (Fig. 21). For this purpose, with the heat direction finder operating in the T-I mode, use the direction control knob to set the gates in the area of the target group (the supposed location of the target in the noise conditions). Set the SYST (СИСТ.) selector switch to the T-II position. In this case the gates on the indicator screen will jump to the screen centre and the scanning field section of 15° in azimuth and 6° in elevation will be displayed thereon.

Shifting the direction knob, bring the selected target mark into the gate centre and lock on the target. After locking on the target, the heat direction finder automatically changes over to the T-III mode.

130. After locking on the target, fly the aircraft by reference to the aiming circle, maintaining the assigned step-up (step-down) separation of the aircraft relative to the target.

131. If the enemy employs the ECM means limitedly, complete the attack with subsequent transition to operation with the airborne radar without the target search from the quasi-scanning mode. For which purpose, after locking on the target by the heat direction finder, use the direction control knob to align the centre of the airborne radar range finder zone with the quasi-scanning range mark and press the LOCK-ON (ЗАХВАТ) button. Further on, take an aim and launch the missiles in the same way as when employing the airborne radar.

132. If the enemy employs the ECM means intensively, complete the attack in the T-III mode.

Check the target range by reference to the quasi-scanning mark or information delivered from the ground control post. At a range close to the permissible launching range, set the SYST (СИСТ.), φ_b - WITH RDR - φ_o ($\varphi_л$ - С РЛС - φ_o) and RHS - FHS (ЗПС - ППС) selector switches to the T-III, φ_b and RHS or FHS (depending on the attack hemisphere) positions, respectively. When the Р-40РД missiles are available aboard the aircraft, the continuous illumination channel is switched on for irradiation (the continuous illumination channel (CIC) signal lamp comes on).

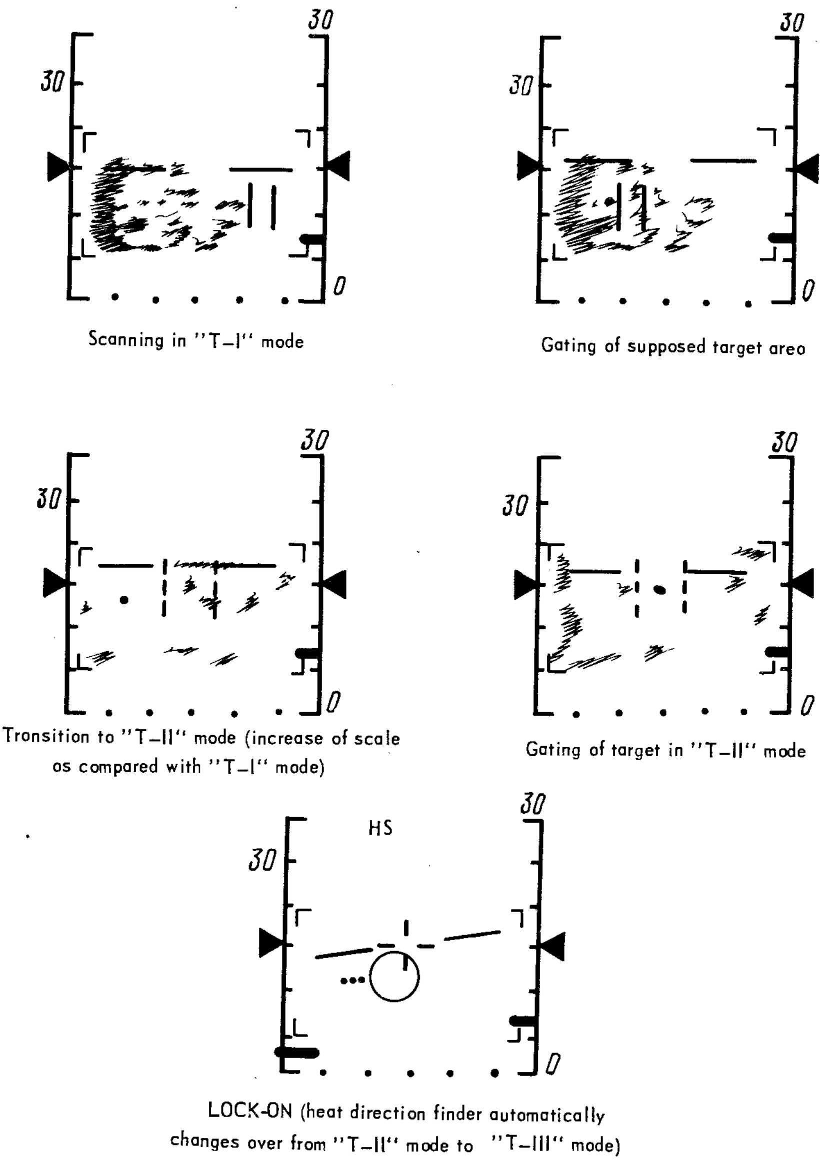


FIG. 21. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF HEAT DIRECTION FINDER IN "T–I" AND "T–II" MODES

(rear-cone attack, direction of fighter by voice, operation of heat direction finder without airborne radar, manual aircraft control mode)

Take an aim by flying the aircraft so that the aiming circle and the target blip are aligned with the electronic crosshairs.

133. Launch missiles Р-40ТД, Р-40РД, Р-40Т in the area of the recommended ranges if even one of signals 1, 2, 3, 4 and the LP signal lamp come on, irrespective of the position of the aiming circle.

For launching missiles Р-60 or Р-60М, set the OUTBD - AUTO - INBD (ВНЕШН. - АВТОМ. - ВНУТР.) selector switch to the OUTBD position. Launch missiles Р-60 and Р-60М if even one of signals 1, 4, LP is available and the monotonous audible signal is heard in the earphones.

After launching the missiles, break off from the attack.

In launching missiles Р-40РД, illuminate the target while breaking off from the attack.

4.6. PECULIARITIES OF DESTRUCTION OF MANEUVERING AIR TARGET

134. After acquisition of the target, energetically maneuver the aircraft to coincide the moment of the target blip appearance with displaying of the number of line 2 or 3 on the indicator screen. Further on, keep the target within the recommended scanning zone by maneuvering the aircraft or setting the ΔH selector switch to the UP (ВЕРХ) or DOWN (НИЗ) position, respectively.

If the target performs the course maneuver at the stage of acquisition, timely deflect the direction control knob to shift the scanning zone so that the target is within the boundaries of the indicator screen. Maneuver the aircraft so as to hold the target blip on the zero azimuth line.

With the target aspect angle varying, timely set the FHS - LST - RHS (ППС - МСЦ - ЗПС) selector switch to the respective position.

135. Peculiarities in launching the attack against the maneuvering target with its escape into the ground clutter background are the following:

- due to the fact that the range of the target acquisition and lock-on by the airborne radar operating in the LA (МВ) mode is considerably less than the range when the radar operates in the HMA (БСВ) mode, the target lock-on failure may occur after escaping the target into the ground clutter background;

- the beginning of the target maneuver may be detected with a certain delay if the information on the target flight altitude delivered from the ground control (direction) post is updated at the low rate.

136. At the stage of the ground direction, when attacking the targets maneuvering in the vertical plane at the low and medium altitudes, fly the aircraft in the director control mode in the lateral channel, and in the longitudinal channel, manually maintain the constant step-up separation with the ascending maneuver of the target or the step-down separation with the descending maneuver of the target.

137. After locking on the target, eliminate the aiming errors. Launch the missiles in the permissible launching range area.

138. When attacking the target from the rear hemisphere, to execute the stealthy attack, if possible, use the heat direction finder in the T-I mode before the target lock-on, with the subsequent transition to the T-III mode after the target lock-on.

4.7. PECULIARITIES OF DESTRUCTION OF GROUP AIR TARGET

139. The attack launched against the group air target features a number of peculiarities depending on the capabilities of the airborne radar and missile homing heads to discriminate (select) one target from the group.

The separate (selective) observation of the targets in the group displayed on the indicator screen of the airborne radar is practically possible if the distance between the targets exceeds the specified values (refer to Table 13) that depend on the radar operating conditions.

Fig. 9 illustrates the resolution intervals of the group target. The heat direction finder features the better resolving power as compared with that of the airborne radar.

The P-40T (P-40TД) missile also possesses the better resolving power as compared with that of missile P-60 (P-60M).

If the intervals and distances between the targets are less than the resolving power in azimuth and range in the autotracking mode, the airborne radar will track not one of the aircraft of the group but their power mid-point.

In this case, the attack against the target, with the radar operating in the autotracking mode, is hampered to some extent, and the probability of the target hit by the missiles is greatly reduced.

The timely identification of the group target makes it possible for the pilot to select the correct tactical method for attacking the target with due allowance for the armament system capabilities. If, with the airborne radar operating, the interval or distance between the targets in the group is less than the resolved ones, if possible, use the heat direction finder and, in some cases, vary the airborne radar operating conditions for the separate (selective) observation of the targets in the group.

Determine the nature of the target (group or single one) by the information received from the ground control post and by reference to the target blip displayed on the indicator screen of the airborne radar. The acquisition range of the single target is somewhat less than the group one comprising several aircraft of the same type as the single target.

140. With the distance and interval between the targets in the group being close to those resolved by the airborne radar, the group target strength can be determined.

The selected target lock-on is possible provided the target is separately observed on the indicator screen and can be gated. In this case, use the manual gating of the target.

141. Accomplish the target selection in range as follows:

- when launching the rear-cone attack against the group target aircraft close to the fighter, impose the gates on the target blip so that the target blip is arranged in the upper section of the lock-on zone;

- when launching the rear-cone attack against the group target aircraft remote from the fighter, the target blip should be arranged in the lower section of the lock-on zone;

- when launching the front-cone attack against the group target aircraft remote from the fighter, there is a certain difficulty in execution of the target lock-on from the first attempts, therefore it is recommended to launch the attack against the target close to the fighter. In this case, it is necessary to bring the lock-on zone gates to the assigned blip from the less distance so that the blip is arranged in the upper section of the lock-on zone.

142. If the group target is displayed on the indicator screen as a single blip, and the heat direction finder cannot be used (due to the forward-cone attack, light spots, failure of the heat direction finder, etc.), gate and lock on the group target in the same way as in case of a single target. The selection of the target to be attacked is hampered in this case. As a rule, the target close to the fighter is locked on and tracked.

In the rear-cone attack of the target remote from the fighter, set the FHS - LST - RHS (ППС - МСЦ - ЗПС) selector switch to the RHS position to lock on and track this target.

Increase in the mobility of the beam mark, command mark and jumpy movement of the present range mark indicate that the airborne radar tracks several targets at a time (their power midpoint).

The unsteady tracking of the target by the airborne radar results in the unsteady tracking of this target by the missile homing heads.

While the beam mark mobility increases or the present range mark jumps, the LP index and lamps 1, 2, 3, and 4 may flicker. In these conditions, proceed approaching the target, without resetting the lock-on button.

With decrease in the distance to the group target the resolution of the data by the sight occurs at the less intervals due to which the airborne radar may change over to the steady tracking of one target.

When attacking the group target, the automatic control of the aircraft is selected when the target is steadily locked on.

143. Select the missile launch variant depending on the tactical situation, but in this case it is necessary to take into account that the probability of hitting the group target by the infrared homing missiles is higher than by the radar homing missiles.

The P-40РД missile does not ensure the accuracy in aiming at the target flying in the formation at an interval of 100 to 200 m, with the airspeed difference being less than 7 m/s.

If the group target combat formation does not allow accomplishment of the steady lock-on and tracking of the single aircraft discriminated (selected) from the group, proceed approaching till the target is visually detected and then attack it in the "φ_0" mode, aiming by reference to the K-10T collimating sight.

144. If the enemy aircraft fly at the intervals less than the infrared homing head resolution interval, take an aim against one of the group aircraft and launch the missile as soon as the LP lamp comes on and any of indices of the infrared homing missiles lights up.

When approaching the group target, the infrared homing head selects independently one target having the most intensive heat radiation. It is impossible to determine beforehand what aircraft of the enemy group target will be hit. However, it is necessary to expect that after destruction of even one aircraft of the group target, the enemy will break up its combat formation and start maneuvering thus creating the conditions for the individual selection of the target.

4.8. PECULIARITIES OF DESTRUCTION OF LOW-SPEED AND LOW-ALTITUDE TARGET

145. The armament sighting system ensures destruction of the low-speed air targets (the helicopters, parachute targets, etc.) in all specified operating modes of the airborne radar.

Prior to attacking the low-speed targets, set the FHS - LST - RHS (ППС - МСЦ - ЗПС) selector switch to the LST position.

146. While attacking the target, the false target lock-on or tracking by the airborne radar may occur.

Determine the change-over of the airborne radar to the false target tracking (in presence of the additional light spots on the indicator screen in the area of the target) only by the increased mobility of the maximum permissible launching range ($D_{max.\ perm}$) mark. The trustworthy information on the false target lock-on and tracking is absent.

147. Execution of the attack against the low-speed target in the LA mode presents no difficulties.

4.9. PECULIARITIES OF DESTRUCTION OF AIR TARGET AT GREAT ASPECT ANGLES

148. Execution of the attack at the assigned aspect angle may be effected only at the strictly defined ratio between the fighter and target airspeeds.

The most efficient attack at the great aspect angles may be launched with the use of the fighter automatic control system.

149. At the stage of the long-range direction, fly the aircraft in the manual, director or automatic control mode. The particular attention should be paid to correspondence of the present airspeed and course to those delivered from the ground control (direction) post. When the aircraft is directed by voice from the PPR by the command delivered from the ground control (direction) post, cut in the radar for illumination and set the direction control knob to the position corresponding to the direction of the attack.

In the automated direction, when the command to cut in the radar for illumination is automatically delivered, check correspondence of the airborne radar antenna position to the direction of the attack. Should the target be not detected at the expected range, change over to the manual control of the airborne radar. After detecting the target, strictly maintain the assigned speed and course.

150. While approaching, the target blip should not vary its azimuth position. When keeping the airspeed less than the assigned one, the target blip will move to the screen centre (entry into the rear hemisphere). When keeping the airspeed more than the assigned one, the target blip will move to increase the azimuth (entry into the front hemisphere).

With increase in the angle of sighting of the airborne radar antenna up to 45 to 50°, to preclude the target loss, perform the correction turn of the aircraft to the target to decrease the angle up to 35 to 40°. Identify the target and lock on the latter.

When the automatic control mode is selected, prior to locking on the target, disengage the autopilot.

After locking on the target, hold the previous course. As the fighter approaches the target, the aiming (command) circle moves towards the crosshairs, whereas the beam mark remains in the constant azimuth.

In response to the "Zoom" command, eliminate the aiming errors.

Pay the particular attention to the fact that the aiming circle centre is located at a distance of not more than by 1.5 dimensions of the electronic crosshairs from the crosshairs centre.

Launch the missiles within the permissible launching range zone.

4.10. PECULIARITIES OF DESTRUCTION OF HIGH-ALTITUDE AND HIGH-SPEED AIR TARGETS

151. The air combat conducted at the supersonic airspeeds and maximum reference altitude features the following peculiarities:

- high closing speed at the stage of the ground direction and while executing the attack, especially the forward-cone attack;
- interception of the dynamic altitudes by the aircraft in case of the great step-up separations of the target;
- degradation of the aircraft maneuvering performances in the stratosphere;

- constraint of the pilot's actions when flying with the high-altitude equipment put on.

152. Climb to the reference altitude and accelerate the aircraft according to the reheat or combined program.

When flying according to the combined program, set the levelling-off altitude value on the ground and in response to the "Reheat" command, set only the assigned Mach number.

When attacking the targets at the supersonic and maximum reference altitudes, the aircraft automatic control advantages are most completely implemented, especially when using the programmed climbing modes. Therefore, if possible, fly the aircraft in the automatic control mode.

153. When launching the forward-cone attack of the targets flying with a step-up separation of 3 km and more relative to the fighter, the "Preliminary zoom" command is delivered.

The aircraft is changed over to a climb with a pitch angle of 5^{o} automatically (in the automatic control mode) or by the pilot (in the director control mode).

154. After identifying the target, lock on the latter. On delivery of the "Aiming zoom" command, energetically execute the aiming zoom maneuver (with the aircraft flying in the automatic control mode, check for execution of the aiming zoom maneuver by the aircraft). Launch the missiles at the maximum permissible launching range (it is allowed to press the firing button together with the LOCK-ON one).

For increasing the probability of destruction of the high-speed and high-altitude target, it is expedient to launch two missiles in series, for which purpose set the SERIES - SINGLE (СЕРИЯ - ОДИН) selector switch to the SERIES position.

155. The pilot's actions in attacking the high-speed and high-altitude targets into the rear hemisphere do not feature the peculiarities.

156. In launching the concealed forward- and rear-cone attacks against the high-speed and high-altitude targets when the enemy employs the electronic countermeasures, use the heat direction finder with subsequent transition to operation of the airborne radar.

Missiles Р-40ТД may be launched into front and rear hemispheres of the high-speed and high-altitude targets.

4.11. PECULIARITIES OF DESTRUCTION OF AIR TARGET WHEN IT IS ATTACKED FROM FRONT HEMISPHERE AT LOWER LIMIT OF AIRBORNE RADAR OPERATION

157. The underneath forward-cone attack against the target flying at an altitude of 1500 m is characterized by the low range of acquisition (20 to 24 km). The acquisition range mainly depends on the fighter flight altitude and the step-up separation of the target relative to the fighter. The less is the flight altitude of the fighter, the greater (with respect to the maximum range) are the light spots on the airborne radar screen. The less is the step-up separation of the target relative to the fighter, the less is the range at which the target enters the acquisition zone of the airborne radar.

The optimum conditions for detecting the target at the maximum range are the fighter flight altitude of 700 m with the step-down separation relative to the target being 700 to 800 m.

When eliminating the direction errors, avoid the rolls exceeding 30°, since this leads to the sharp light spotting of the airborne radar screen by the ground clutter.

158. Bring the aircraft to the target at an aspect angle of 0/4 to 1/4, with the sighting angle being equal to 5 to 10°. The low acquisition ranges, execution of the flight at the low altitude, limited time for performing the attack call for the greater attention in piloting the fighter and handling the armament equipment.

159. As a rule, the target is locked on at the range at which the "Launch permitted" command is delivered. In this case, the $D_{perm.\ max.\ 2}$ mark is displayed on the airborne radar screen, and the present range mark is located above the $D_{perm.\ max.\ 2}$ one.

Launch the missile at the maximum permissible range, without waiting for coincidence of the present range mark with the $D_{perm.\ max.\ 2}$ one.

After launching the missiles, break off from the attack in the direction opposite to the target in response to the "Breakaway" command, ensuring the target illumination for the missiles furnished with radar homing head.

4.12. PECULIARITIES OF DESTRUCTION OF AIR TARGET FLYING BELOW FIGHTER WITH USE OF AIRBORNE RADAR

160. When attacking the target flying below the fighter, use is made of the HMA-ΔH or LA operating mode of the airborne radar.

The HMA-ΔH mode is selected when flying the aircraft at an altitude above 1500 m by setting the ΔH selector switch to one of the DOWN (НИЗ) positions corresponding to the assigned step-up separation of the fighter relative to the target.

161. The optimum conditions for executing the attacks for obtaining the maximum coverage of the airborne radar in the HMA-ΔH mode are ensured when the step-up separation of the fighter relative to the target does not exceed two flight altitudes of the target. The maximum step-up separation of the fighter relative to the target should not exceed 5000 m.

162. With the airborne radar operating in the HMA-ΔH mode, the separate light spots are displayed on the indicator screen caused by the false blips, mainly, at the ranges exceeding the potential coverage of the airborne radar.

163. The LA mode is selected when flying the aircraft at an altitude below 1500 m by setting the ΔH selector switch to any of the DOWN (НИЗ) positions. The scanning zone in azimuth and elevation is not controlled.

The target may be detected only within the range of 0.3 to 18 km (when the range mark produced by the 5У15К-11 equipment at the automatic direction or the gate middle mark in the manual control mode at a distance less than 15 km is displayed) or 9 to 27 km (when the range mark produced by the 5У15К-11 equipment or the gate middle mark at a distance more than 15 km is displayed).

164. If the foreign light spots hinder the target lock-on, change over to the manual gating of the target by turning the direction control knob clockwise all the way home.

165. Depending on the target own airspeed, the target acquisition is occasional. The mark may appear in each scanning cycle, once every two cycles, three cycles, etc., and may not be displayed at all on the indicator screen.

166. The most optimum step-up separation of the fighter relative to the target amounts to 500 m. In this case, avoid flying the aircraft at an altitude close to the mode-selection altitude (1500 m).

167. The target lock-on is steady. The target lock-on failure is doubtful. In case of the false lock-on of the target, immediately reset the target lock-on and lock on the target anew.

After locking on the target, do not try to eliminate the aiming errors in elevation at once. Perform this maneuver at a distance of 1 to 1.5 km to the maximum permissible launching range, otherwise the fighter may approach the target altitude when the target flies at an altitude of 500 m and higher or approach an altitude of 500 m, with the target flying at the altitudes below 500 m.

168. After locking on the target, before the "Zoom" command is delivered, switch off the automatic control system (if it has been switched on) and approach the target, piloting the aircraft in the director or manual control mode. Determine the aiming errors by deflection of the great circle from the crosshairs centre and by reference to the flight director indicator deviation bars (when the DIRECTION (НАВЕДЕНИЕ) mode is switched off) or only by reference to the flight director indicator deviation bars (when the DIRECTION mode is selected).

Launch the missiles within the permissible launching range.

On the "Breakaway" command, break off from the attack, ensuring the illumination of the radar homing missiles.

169. When the airborne radar operates in the LA mode, the radar ensures the execution of the forward-cone attacks against the large-size targets at an aspect angle of 0/4 to 1/4.

170. The most probable hit of the target in the forward-cone attack occurs when the missiles are launched from the outer boundary of the in-range zone.

171. Interception of the target by the fighters at a sighting angle of about 5 to 10° and the smooth breaking off from the attack with subsequent climb just after launching the missiles ensure the safety in execution of the attack.

4.13. PECULIARITIES OF CONDUCTANCE OF AIR COMBAT IN CLOUDS

172. The execution of the flight for air combat in clouds calls for the constant instrument flying of the aircraft and is characterized by the effect of clouds on the airborne radar operation, by impossibility of use of the heat direction finder and infrared homing missiles.

When flying the aircraft for the air combat in clouds, the ground direction stage should be, as a rule, automated, and the aircraft control mode, automatic or director one.

If the fighter is controlled by voice over the radio with the use of the radar plan-position repeater at the ground direction stage, it is advisable to use the attitude stabilization mode.

Depending on the radio contrast, the clouds affect the operation of the airborne radar in a different way.

The high clouds (cirrus, cirrostratus, cirrocumulus), as a rule, do not affect the operation of the airborne radar. The target blip is distinctly displayed on the indicator screen, no light spots are observed.

The medium clouds (alto-stratus, alto-cumulus) considerably affect the operation of the airborne radar as compared with the effect of the high clouds.

The dense low clouds (nimbostratus, fractostratus, stratus, stratocumulus) mostly affect the operation of the airborne radar as compared with the effect of the high and medium clouds. In attacking the target under conditions of such clouds the signals reflected from the clouds may be locked on (false lock-on) and automatically tracked.

173. The symptoms of the false lock-on are:

- discrepancy between the actual maximum or minimum permissible launching range and the estimated one;
- disordered motion of the aiming circle or its evident non-conformity to the target position;
- change in the mutual position of the maximum and minimum permissible launching range marks ($D_{perm.\ max.} < D_{perm.\ min.}$);
- slow motion of the present range mark to increase the value;
- quick motion of the present range mark to the zero value;
- nonconformity of the beam mark (dot) position to the actual direction to the target.

Presence of any of these symptoms indicates that the airborne radar has locked on the false target. The untimely identification of the false target lock-on may lead to failure of the attack.

174. In the conditions of the intensive atmospherics the most effective is the attack against the target with use of the ground automatic control system, as by reference to the position of the range mark produced by the 5Y15K-11 equipment the approximate position of the target in range may be determined, which facilitates discrimination of the target among the light spots caused by the clouds.

When attacking the air targets in the conditions of intensive atmospherics, it is necessary to timely select the operating mode of the airborne radar by varying the fighter flight altitude and by setting the ΔH selector switch to the assigned position.

A certain nature of light spots displayed on the indicator screen corresponds to each operating mode of the airborne radar.

In the HMA mode, in presence of inconsiderable clouds, the separate blips (light spots) appear on the indicator screen, allowing, with a certain decrease in the acquisition range, the correct discrimination of the target blip. Lock on the target with use of gating in angles and range.

In the HMA-ΔH mode, the separate light spots are displayed on the indicator screen, caused by the false marks, mainly at the ranges exceeding the potential coverage of the airborne radar due to effect of the ground echo.

Presence of the radiocontrast clouds within the scanning zone of the airborne radar inconsiderably affects the quantity of false marks displayed thereon, but may lead to disappearance of the target blip on the indicator screen. In this case, the indicator screen is quite clear. Therefore, when the airborne radar operates in the HMA-ΔH mode, determine the real weather conditions not by presence of the light spots on the indicator screen, but visually.

If the air targets flying in the radiocontrast clouds cannot be attacked, with the airborne radar operating in the MLA, HMA or HMA-ΔH modes, use the ATMOSPHERICS (МПХ) mode.

When the airborne radar operates in the ATMOSPHERICS mode, the forward-cone and rear-cone attacks are ensured against the air targets flying at the altitudes above 2000 m with the step-down separation of the fighter relative to the target or at the same altitude.

The rear-cone attack is ensured when the target flies at the altitude of not less than 1000 m, with a certain step-down separation of the fighter relative to the target.

Launch the overhead attacks only against the targets flying at the altitudes of 3000 m and higher, with the step-down separation of the target relative to the fighter being within 1000 to 2000 m.

In presence of cumulus, containing the heavy concentration of rain or snow, a great number of dotted light spots, extremely hindering the acquisition and lock-on of the target, appear on the indicator screen. Cutout of the parametric amplifier in these conditions does not lead to the noticeable decrease of the light spots on the indicator screen.

When the airborne radar operates in the ATMOSPHERICS (МПХ) mode, the sighting system capabilities in detecting and locking on the target are substantially lower (by 1.5 to 2 times) and, hence, the aircraft interception complex capabilities are also reduced due to limitation of the time available for executing the attack.

The great effect on the airborne radar operation is exerted by the mutual position of the target and fighter with respect to the clouds.

If the target flies in the clouds, approach the target, if possible, also in the clouds. In this case, the intensity of the light spots on the indicator screen is less than that in case of approaching the target under the clouds.

Since the probability of locking on and relocking on the false targets is rather high when the target is attacked in the radiocontrast clouds, it is necessary to change over to the director aircraft control mode before locking on the target when piloting the aircraft in the automatic control mode.

4.14. OPERATION OF AIRBORNE RADAR UNDER JAMMING CONDITIONS

4.14.1. Operation of Airborne Radar under Conditions of Passive Jamming

175. When attacking the target-jammer from the rear hemisphere and when the target-jammer dispenses the chuffs into the rear hemisphere, the pilot should:

- set the ACT JAMM - OFF - PASS JAMM (АП - ВЫКЛ. - ПП) selector switch to the PASS JAMM position;
- set the range finder gate middle mark to the range of the chaff trail leading edge;
- press the LOCK-ON button;
- after appearance of the gates, impose them on the chaff trail so that the trail leading edge is arranged closer to the lower gate and hold them in this position till lock-on.

176. When attacking the target-jammer from the front hemisphere and when the jammer sets up the passive jamming by dispensing the chaffs into the rear hemisphere, lock on the target just as in case of locking on the target that does not use the countermeasures.

177. When attacking the target, dispensing the chaffs, at the aspect angles close to 4/4, the lock-on is reset. In this case, it is necessary to decrease the attack aspect angle and lock on the target once more.

178. For attacking the target flying in the chaff cloud, select the ATMOSPHERICS (МПХ) mode.

4.14.2. Operation of Airborne Radar under Conditions of Continuous and Intermittent Noise and Combined (Continuous, Intermittent Noise and Passive) Jamming

179. At the automated direction, after appearance of the noise jamming signal in the scanning mode and display of the ACT JAMM (АП) signal, the pilot should:

- cut off the parametric amplifier at the flight altitudes of 4500 m and higher;
- set the ACT JAMM - OFF - PASS JAMM selector switch to the ACT JAMM position;
- turning the radar knob, obtain the position at which only one noise vertical flight spot of 3 to 5° in width remains on the indicator screen;
- lock on the target-noise jammer.

180. At the manual direction, when the noise jamming signal appears in the scanning mode, perform all the operations before the target lock-on occurs in the same sequence as at the automatic direction.

After locking on the target-noise jammer, provided the information on the distance to the target-noise jammer is delivered from the ground control direction post, set the range mark in compliance with the delivered information. When the range mark is within the permissible launching range zone, the LP (ПР) signal lamp is lighting and even one of signals 1, 2, 3, 4 is applied, launch the missiles.

4.14.3. Operation of Airborne Radar under Conditions of Multiple Discontinuous and Repeater Noise Jamming

181. At the automated direction for locking on the target-jammer, setting up the multiple discontinuous or repeater noise jamming, the pilot should:

- cut off the parametric amplifier;
- set the ACT JAMM - OFF - PASS JAMM selector switch to the ACT JAMM position.

If one noise light spot remains on the indicator screen, lock on the target-jammer. Otherwise, turn the radar knob to obtain one light spot (only in attacking the targets flying below the fighter, with the airborne radar operating in the ATMOSPHERICS (МПХ) mode); this done, lock on the target.

4.14.4. Operation of Airborne Radar under Conditions of Range-Distorting Discrete Discontinuous Jamming

182. At the automated direction, in case of the periodical sharp oscillations of the maximum permissible launching range mark or in case of reset of lock-on in range (fadeout of the ATK (A) lamp), set the ACT JAMM - OFF - PASS JAMM selector switch to the ACT JAMM position, lock on the target anew and approach the target-jammer.

In case of lighting-up of the LP (ПР) lamp and even one of lamps 1, 2, 3, 4 comes on, launch the missiles.

183. When directing manually, act in the same way as in case of the automated direction. After setting the ACT JAMM - OFF - PASS JAMM selector switch to the ACT JAMM position, use the direction control knob to introduce the range.

4.14.5. Operation of Airborne Radar under Conditions of Combined (Noise Repeater and Passive) Jamming

184. The pilot's actions in locking on the target, setting up the combined (noise repeater and passive) jamming, are similar to those taken in case of locking on the target, setting up the noise repeater jamming.

4.14.6. Operation of Airborne Radar under Conditions of Combined (Range-Distorting and Passive) Jamming

185. The pilot's actions in locking on the target, setting up the combined (the range-distorting and passive) jamming, are similar to those taken in case of attacking the target, setting up the range-distorting discrete discontinuous jamming.

4.14.7. Operation of Airborne Radar under Conditions of Combined (Multiple Discontinuous and Passive) Jamming

186. The pilot's actions in locking on and attacking the target, which sets up the combined (multiple discontinuous and passive) jamming, are similar to those used in case of locking and attacking the target, which sets up the multiple discontinuous or noise repeater jamming.

4.14.8. Operation of Airborne Radar under Conditions of Two-Point Flickering Noise Jamming

187. The pilot's actions when the airborne radar operates in the scanning and lock-on modes are similar to those taken under the conditions of the continuous and intermittent noise and combined (continuous and intermittent noise and passive) jamming.

188. When the flickering jamming is set up, it is recommended to use the infrared homing missiles.

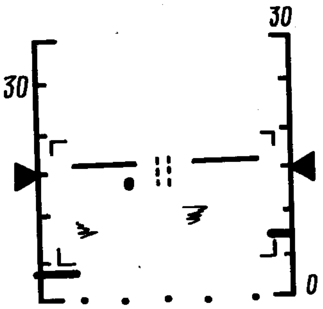
4.15. PILOT'S ACTIONS IN CASE OF FAILURE OF ARMAMENT CONTROL SYSTEM

189. In case of the complete failure of the airborne radar (which is indicated by lighting-up of the RDR (РЛС) lamp on the indicator screen bezel), proceed as follows:

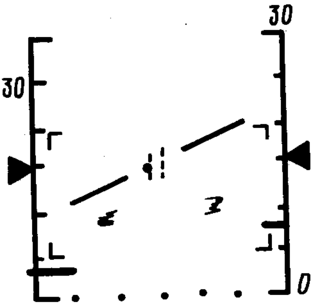
- cut off the airborne radar;
- attack the target with use of the heat direction finder operating in the "T-φ_{oI}" mode with subsequent change-over to the "T-φ_{oII}" mode.

For attacking the target, with the heat direction finder operating in the "T-φ_{oI}" mode (Fig. 22), the pilot should:

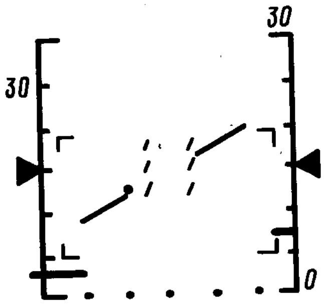
- set the SYST (СИСТ.) selector switch to the "T-φ_{oI}" position;
- set the φ_b - WITH RDR - φ_o ($\varphi_л$ - С РЛС - φ_o) selector switch to the φ_o position;
- set the RHS - FHS (ЗПС - ППС) selector switch to the RHS or FHS position (depending on the conditions of the attack);
- after detecting the target, approach it to a distance close to the missile launching range (by the information delivered from the ground control (direction) post or by visually determining the target range);



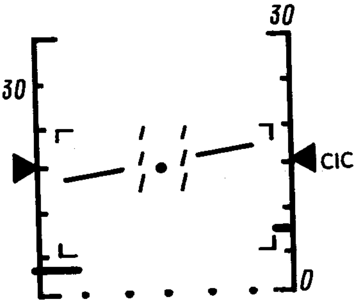
Detection of target in "T–φ_{ol}" mode



Aiming in "T–φ_{ol}" mode



Transition to "T–φ_{oll}" mode



Aiming in "T–φ_{oll}" mode
(selector switches are to be set
to φ_o, RHS positions)

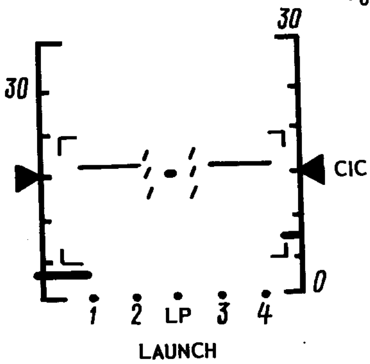


FIG. 22. IMAGES OF RADAR DISPLAY AT VARIOUS STAGES OF AIR COMBAT DURING OPERATION OF HEAT DIRECTION FINDER IN "T – φ_{ol}", "T – φ_{oll}" MODES

- maneuvering the aircraft, bring the target blip into the middle portion of the heat direction finder field till the blip gets in contact with gate "T-φ_{oI}";

- set the SYST selector switch to the "T-φ_{oII}" position;

- turn on the MASTER ON (ГЛАВН. ВКЛЮЧ.) switch;

- piloting the aircraft, set the target blip within the zone limited by gates T-φ_{oII};

- launch the infrared homing missiles within the zone of recommended ranges.

190. In case of the partial failure of the airborne radar, excluding the possibility of controlling the airborne radar antenna by the heat direction finder (in the scanning mode, the azimuth beam mark remains motionless or, when locking on the target, the great discrepancy occurs between the aiming circle and the beam mark with the subsequent reset of the lock-on), proceed as follows:

- attack the target with the use of the heat direction finder operating in the "T-φ_{oI}" mode with the subsequent transition to the "T-φ_{oII}" mode when the continuous illumination channel (CIC) operates in the HORN ANTENNA (РУПОРНАЯ АНТЕННА) mode.

For attacking the target, proceed as follows:

- use the RDR (РЛ) selector switch to check the airborne radar for engagement;

- set the SYST (СИСТ.) selector switch to the T-φ_{oI} position;

- after detecting the target, set the φ_b - WITH RDR - φ_o ($\varphi_л$ - С РЛС - φ_o), FHS - RHS (ППС - ЗПС) selector switches to the φ_o, FHS or RHS (depending on the direction of the attack) positions, respectively;

- if the fighter carries missiles Р-40РД, check lighting-up of the continuous illumination channel (CIC) lamp on the indicator screen bezel;

- at the range close to the maximum permissible launching one, set the SYST selector switch to the T-φ_{oII} position and execute the precise aiming;

- launch the missiles provided with infrared or radar homing heads within the maximum permissible launching range zone.

191. In case of failure of the continuous illumination channel (in the front-cone attack, after the target lock-on the continuous illumination channel (CIC) lamp does not light up on the indicator screen bezel; in the rear-cone attack, 22 s before the present range mark approaches the maximum permissible

launching range mark the continuous illumination channel lamp does not light up), attack the target in the "T-φ_{oI}" mode with subsequent transition to the "T-φ_{oII}" mode.

192. In absence of the target lock-on by the airborne radar, proceed as follows:

- take the necessary step-down (step-up) separation relative to the target for attacking with the use of the heat direction finder;
- attack the target with use of the heat direction finder.

193. In absence of display on the indicator screen, attack the target by aiming visually with the aid of the K-10T collimating sight.

For attacking the target in the "φ_o" mode by aiming visually, the pilot should:

- on detection of the target, maneuver the aircraft to take an aim, aligning the target with the crosshairs of the K-10T collimating sight reticle with an accuracy of ± 20 mrad or better for the long-range combat missiles and ± 40 mrad or better for the close combat missiles;
- turn on the MASTER ON (ГЛАВН. ВКЛЮЧ.) switch;
- at least 1 min and not more than 20 min before launching the missiles, select the φ_b - WITH RDR - φ_o ($\varphi_л$ - С РЛС - φ_o) selector switch to the φ_o position;
- after selecting the "φ_o" mode, set the FHS - RHS (ППС - ЗПС) selector switch to the RHS position;
- after locking on the target by the infrared homing heads (the reticle of the K-10T collimating sight starts flickering), launch the missiles;
- in case of necessity of attacking the target with use of the P-60 missiles, set the OUTBD - AUTO - INBD (ВНЕШН. - АВТОМ. - ВНУТР.) selector switch to the OUTBD position and, as soon as the target is locked on by the P-60 missiles (the audible signal is applied to the earphones), launch the missiles;
- break off from the attack at the maximum g-load just after launching the infrared homing missiles.

4.16. SAFETY MEASURES

The combat mission may be successfully executed provided the certain safety measures are observed.

194. Before flight:

- prior to inspecting the aircraft, make certain that the cabin is empty and the power supply switches are turned off;

- check the safety pins for proper setting and the control elements of the armament control system for being placed in the initial position (the circuit breakers are turned off, the button triggers are latched in the safety position);

- make certain that the suspended weapon corresponds to the assigned combat mission;

- prior to taxiing out, check to see that the ground safety pins are removed from the weapon and there are no obstacles in the direction of taxiing (the safety pins may be removed by the armament specialists prior to taxiing out to the runway);

- in case of takeoff from the contaminated airfield, use the pure oxygen for breathing, with the cabin pressurization system being switched off.

195. In flight:

- maintain the established combat formation;

- keep looking around;

- prior to engaging the air combat, change over to pure oxygen supply.

196. When conducting the air combat:

- lock on the target after the latter has been identified;

- after locking on the target, make certain that the false lock-on does not occur; in case of the false lock-on, reset it and then lock on the target anew;

- when flying in the formation, launch the missiles by the leader's command, observing the missile launching conditions;

- after hitting the target, break off from the attack at a distance excluding the collision of the fighter with the wreckages of the target and missiles;

- in case of explosion of the missiles on the flight path, fly the aircraft through the burst centre;

- when detecting the attacking enemy, evade the enemy attack by performing the fighter (missile) evasion maneuver;

- prior to entering the zone contaminated with the radioactive or bacteriological substances as well as prior to entering the chaff cloud, change over to pure oxygen supply, switch off the cabin pressurization system, turn on the PITOT, ДУА HEATING (ОБОГРЕВ ПВД, ДУА) switch.

When flying in the zone of cooperation with the antiaircraft missile troops, strictly maintain the established flight regime.

197. After flight:

- before landing on the contaminated airfield, change over to pure oxygen supply and switch off the cabin pressurization system;
- after landing the aircraft with the unused weapon, taxi to the allotted place, turn the aircraft in the safe direction, switch off the armament control system, shut down the engines and deenergize the aircraft;
- after landing the aircraft on the contaminated airfield, put on the protection means.

Chapter 5

DIRECTION OF МиГ-25ПД (МиГ-25ПДС) FIGHTER TO AIR TARGETS

5.1. MAXIMUM DESTRUCTION LINES WITH RESPECT TO FUEL RESERVE AND AIR COMBAT FLIGHT PROFILES

198. When estimating the maximum destruction lines with respect to fuel reserve, the following conditions are taken as initial ones:

- the takeoff mass of the aircraft carrying four missiles Р-40Д is 37,620 kg;
- usable fuel amount is 14,520 kg;
- fuel density is 0.845 g/cm^3;
- fuel consumption required for starting the engines is 150 kg;
- fuel consumption required for running the engines on the ground (running up by the pilot, taxying) is 70 kg/min;
- fuel consumption when approaching from the estimated point of turn to the runway landing heading till landing with the use of the POLJOT-1И system is 550 kg (fuel consumption for descent from the estimated point from an altitude of 2000 m and at a distance of 35 to 40 km till landing is 800 kg);
- fuel consumption in circling flight or at missed landing approach with use of the POLJOT-1И system is 120 kg/min with the LG up and 220 kg/min with the LG down;
- the guarantee fuel reserve which amounts to 7% of the consumable capacity of the inner tanks, taking allowance for possible differences of fuel consumption characteristics given in the present Manual from the actual ones due to the spread of the engine parameters and aircraft aerodynamic characteristics, is 1000 kg;

- the atmospheric conditions are standard, zero wind;
- the target attack accomplished, the fighter flies to the landing airfield without missiles;
- landing on the takeoff airfield after accomplishing the combat mission.

199. The flight profiles, ensuring destruction of targets within the range of altitudes and airspeeds of combat employment of the МиГ-25ПД fighter, are estimated with respect to the fuel consumption characteristics of the МиГ-25ПДС aircraft and given in Figs 14 through 25.

5.2. PROGRAMMED FLIGHT CONDITIONS OF FIGHTER FOR AIR COMBAT

200. In the modern automated control systems, direction of fighters to air targets is solved by elaboration of the air combat flight program. These programs are characterized by the flight profile, engine power setting, reference altitude and fighter final speed.

The air combat flight program is chosen with respect to:
- radar information field depth;
- target flight conditions;
- distance to the assigned destruction line;
- tactical intention and target attack direction.

The program of gaining of the assigned altitude and airspeed by the fighter is delivered by the ground automated control systems or by voice from the control (guidance) post. This program is executed by the pilot in the automatic (director) or manual aircraft control mode.

201. In the air combat flight use may be made of reheat, cruise or combined basic flight programs.

The reheat (short-range) program is used when the air target warning distance is limited by the ground facilities capabilities to obtain the maximum climbing rate at the minimum time available to execute the combat mission.

The combined (middle-range) program is used when the air target warning distance is rather long, when the time available for destruction of the target allows the pilot to use the subsonic speed on the cruising flight leg for increasing the distance to the destruction line.

The cruise (long-range) program is used when the air target warning distance is rather long and the time at the disposal of the pilot to destroy the target is sufficient for selection of the non-reheat engine power settings for ensuring the maximum destruction lines.

202. When the fighter flies according to one of the said programs, the programmed speed and the instant of selection of the reheat power setting are transmitted to the fighter. The programmed speeds have the following discrete values:

V_1 = 2500 km/h (M_1 = 2.35);
V_2 = 1900 km/h (M_2 = 1.8);
V_3 = 1500 km/h (M_3 = 1.4);
V_4 = 1000 km/h (M_4 = 0.85).

5.3. DIRECTION OF МиГ-25ПД (МиГ-25ПДС) FIGHTER WITH USE OF RADAR PLAN-POSITION REPEATER

203. The radar PPR-assisted direction of the МиГ-25ПД (МиГ-25ПДС) fighter is performed with the use of the direction plotting board.

The preliminary navigational calculations and leading of the fighter to the initial direction point are accomplished by the combat control officer of the direction plotting board, and the moment the target and fighter (or fighter only) are detected on the radar PPR, direction is continued by the combat control officer of the radar PPR. All the commands required in the process of direction are transmitted to the pilot by the combat control officer over the radio by voice.

While accomplishing the radar PPR-assisted direction, the combat control officer should:

- advise the pilot the attack hemisphere (front or rear);
- determine the reheat selection moment and point of turn to the target;
- inform the pilot on the target range, altitude, angular position with respect to the fighter longitudinal axis;
- timely give the pilot a command to cut in the airborne radar for illumination, to make a zoom, break off from the attack and turn off the reheat;
- lead the fighter to the landing airfield with a guarantee fuel remainder.

When performing the flight for air combat with the use of reheat power settings, determine the reheat selection moment so as to ensure acceleration to an assigned speed, accomplishment of a turn (corrective turn) to the target and interception of the assigned target attack altitude.

The reheat selection distance is calculated by the formulas:

$D_{reheat} = S_{accel} + V_{tgt}\, t_{accel} + D_{turn}$ - in the rear-cone attack;

$D_{reheat} = S_{accel} + S_{H_{assigned}} + D_{lead} + V_{tgt}$

$(t_{accel} + t_{H_{assigned}})$ - in the front-cone attack,

where S_{accel} stands for the distance covered by the fighter during acceleration up to the assigned speed;

$S_{H_{assigned}}$ stands for the distance covered by the fighter during climb to the assigned altitude;

t_{accel} stands for the acceleration time;

$t_{H_{assigned}}$ stands for the assigned altitude climb time;

D_{turn} stands for turn initiation distance;

D_{lead} stands for distance of leading of the fighter with respect to the target.

In directing the fighter into the target rear hemisphere, the turn initiation distance is calculated by the formula:

$$D_{turn} = V_{tgt} \cdot t_{TA} - D_{lead} - R_{mean\ rad} \cdot \sin TA,$$

where t_{TA} stands for the time of turn through the assigned angle;

$R_{mean\ rad}$ stands for the mean radius of turn.

In directing the fighter into the target front hemisphere, the turn initiation distance is calculated by the formula:

$$D_{turn} = V_{tgt} \cdot t_{TA} + D_{lead} + R_{mean\ rad} \cdot \sin TA.$$

When the fighter is directed to the target rear hemisphere at an angle of turn equal to 180°, the D_{turn} and D_{reheat} values are given in Table 16.

The fighter leading distance is calculated by the formulas:

$D_{lead} = 2/3\, D_{launch} + V_{clos}\, (t_{zoom} + t_{atk})$ - in the rear-cone attack;

$D_{lead} = D_{launch\ max} + V_{clos}\ (t_{zoom} + t_{atk})$ - in the front-cone attack,

where t_{zoom} stands for the time spent for accomplishment of zoom;

t_{atk} stands for the time of attack;

$$t_{zoom} + t_{atk} = 1 \text{ to } 2 \text{ min}$$

Table 16

V_{ftr}, km/h	950	1500	1900	2550
V_{tgt}, km/h	800	1200	1600	2400
$H_{assigned}$, km	10	13 to 14	15 to 16	18 to 20
D_{turn}, km	11.5	30	60	140
D_{reheat}, km	-	160 to 170	300 to 310	550 to 570

The values of D_{lead} are given in Tables 17 and 18.

The fighter is led to the target at the following step-down separations with respect to the target:

- 300 to 500 m at low altitudes (up to 1000 m in the rear-cone underneath attack);
- 1000 to 5000 m at medium and high altitudes in the front-cone and rear-cone attack;
- 2000 to 10,000 m in stratosphere in the front-cone and rear-cone attack.

When the airborne radar operates in the HMA-ΔH mode, the vertical step-up separation of the fighter with respect to the target is 1000 to 5000 m, and when attacking the target against the ground (LA mode), 500 m.

In the HDF-assisted rear-cone attack of the target the step-down vertical separation of the fighter with respect to the target should not be more than 500 m (at a low altitude, 300 m).

At the radar PPR-assisted direction the command to cut in the airborne radar for illumination is given so as to ensure detection, target lock-on, aiming and missile launch.

The minimum illumination cut-in distance is calculated by the formula:

$$D_{illum.\ cut\text{-}in} = D_{perm.\ max} + 0.5\ V_{clos},$$

where V_{clos} stands for the closure speed, km/min.

When the fighter is precisely directed to the initial position for the attack, as well as when the heat direction finder is used for a stealthy approach to the target, the command to cut in the radar for illumination (changing over to aiming with the aid of the airborne radar) can be given at the target ranges close to the maximum permissible launching range, but not later than 30 s before the missile launch.

If the target is attacked only by the infrared homing missiles, do not cut in the airborne radar for illumination owing to tactical reasons, take aim with the aid of the heat direction finder. In this case, the combat control officer informs the pilot on the target range.

Table 17

V_{clos}, km/h	100	200	300	400	500	600
D_{lead} in rear-cone attack, km	5 to 6.5	6.5 to 10	8 to 13	10 to 17	12.5 to 20.5	15 to 25

Table 18

V_{clos}, km/h	1800	2200	2600	3000	3400	3600	3800	4200	4600	5000
D_{lead} in front-cone attack, km	45 to 75	52 to 90	58 to 100	65 to 120	75 to 130	80 to 140	85 to 150	90 to 160	100 to 180	105 to 190

204. The direction results depend in many respects on preparation of the working station and observance of sequence of actions by the combat control officer. The working station is prepared just before direction. In the process of preparation of the working station the combat control officer should proceed as follows:

- check the display for tuning;
- set the required scale;
- match the PPR scale with that of the rule or measuring grid;

- use a China pencil to plot the initial direction point, air target assigned destruction line (if necessary, an estimated fighter path of flight for air combat), air alert area, landing airfield and approach heading turn path of the fighter on the protective glass of the PPR screen;

- on the special board or protective glass of the PPR screen, plot the indexes of the directed fighters and call sign of the airfield;

- prepare the estimated and reference data as well as the navigator's aids for direction of the fighter to the target and bringing the fighter to the landing airfield;

- check communication and report on readiness for direction.

205. In the process of direction the combat control officer should proceed as follows:

- as the fighter marker appears on the PPR, check presence of the active answer and identification;

- as the target blip appears on the PPR, determine the target direction and speed;

- transmit the course and altitude to the pilot and, if necessary, give a command to select reheat power;

- when the fighter rolls into the preset course, specify the target moving parameters (course, speed, altitude), use the measuring grid or scale rule to specify the fighter flight parameters or do it by eye;

- 5 to 10 s before the fighter enters the turn initial point, give a command to the pilot to perform the turn and check the process of turning;

- at the estimated target range, give the pilot a command to initiate the target search, inform the pilot on the target location with respect to the fighter in azimuth, distance and altitude difference;

- upon detection of the target by the pilot, check the process of approach and attack and, if the target is lost, help the pilot to detect it;

- the attack over, direct the fighter to the landing airfield.

5.4. PECULIARITIES OF DIRECTING МиГ-25ПД (МиГ-25ПДС) FIGHTER TO AIR TARGETS IN VARIOUS CONDITIONS OF COMBAT SITUATION

5.4.1. Direction to Maneuvering Air Target

206. Direction of the fighter to the maneuvering air target is one of the complex elements of combat control. Difficulty of direction consists in that it is impossible to determine the nature of the target maneuver beforehand, due to that, determination of the track and flight time of the fighter as well as the parameters of the fighter maneuver for bringing the aircraft into the assigned position with respect to the target is difficult. And what is more, information on initiation of a maneuver by the target, obtained with the help of the available radars, is obtained by the combat control officer with a considerable delay. Practically, the combat control officer can detect the maneuver of the target in course only 20 to 30 s after initiation of the maneuver.

Employment of this or that kind of maneuver (in course, speed, altitude or in various combinations) by the enemy makes the combat control officer continuously re-calculate the direction tasks. If the nature of the target maneuver allows the combat control officer to reveal a mean direction of the target flight (averaged flight course), guidance is performed with respect to that direction with regard for actual target coordinates.

207. The actions of the combat control officer and those of the pilot will differ depending on the direction stage, at which the target makes this or that maneuver.

When the target maneuvers in course during the first stage of direction assisted by the automatic control and direction system (ACDS), the fighter is likely to get into the zone where the ACDS-assisted direction task cannot be solved. In this case, the combat control officer changes to manual direction or transmission of direction commands by voice over the radiotelephone. The fighter course in the roll-in initiation point will be changed depending on the direction of the target maneuver, either to the fighter or from it. The directional commands must be fulfilled by the pilot energetically and without delay.

When the target maneuvers in course during the second stage of direction, advised may be turns at a maximum permissible rolls and g-loads. In this case, the task is complicated still more since these maneuvers should be accomplished without loss of speed and quite often at acceleration or retardation.

At the third stage of direction, upon detection of the target, the pilot independently maneuvers after the target, also using the information on the target position and type of its maneuver delivered from the combat control officer.

208. It is difficult for the combat control officer to determine the target maneuver in speed, especially when he directs two or more fighters at one and the same time. That is why, in all cases when the fighter is directed to the target rear hemisphere, the pilot is advised the maximum flight speed for the given altitude at the maximum engine power or with the reheat selected irrespective of the target flight speed. High closure speed will not interfere significantly with accomplishment of attack, and, if necessary, the pilot can disengage the reheat and quickly decrease the speed.

209. When the target maneuvers in altitude, the combat control officer gets the information on the target altitude at a delay of ±300 to 500 m. However, with the capabilities of the МиГ-25ПД (МиГ-25ПДС) fighter airborne radar taken into account, target maneuver in altitude within the limits of 3 to 5 km presents no difficulty for direction. In such cases, the fighter is brought to the optimum reference altitude, from which interception of the target, accomplishing either a climbing or descending maneuver, is ensured. A continuous information on the target flight parameters and mutual position of the target and fighter delivered by the combat control officer to the pilot makes the enemy detection easier for the pilot.

5.4.2. Direction at Low Altitudes

210. Understood as combat actions at low altitudes are the actions of the fighter on interception of air targets at altitudes of up to 1000 m above the terrain relief.

The conditions of the fighter combat actions at low and extreme low altitudes are characterized by the following peculiarities:

- limitation of sizes and noncontinuity of the radar field and command field;
- heavy consumption of fuel and limitation of a maneuver in speed;

- ground proximity that limits the combat control officer in choosing a maneuver and full use of the aircraft maneuverability in horizontal and vertical planes;

- interference of the earth surface with operation of the radar sights which makes it difficult for the airborne radar to detect a target;

- limitation of the possible attack area.

To successfully direct the fighter to a low-altitude air target, the combat control officer must know the radar field, command field at low altitudes, cluttered areas on the radar PPI caused by the local objects, combat capabilities of the aircraft and airborne armament system at these altitudes.

211. As a rule, direction to a low-altitude target is accomplished from the air alert zone and, if the warning depth is sufficient, the fighter is brought to the initial direction point beforehand.

The location of the air alert zones, flight altitude and alert time are determined in compliance with the data specified in Table 19.

Table 19 presents the parameters for flight with four P-40Д missiles aboard and conduction of air combat for 5 min (4 min 20 s at MAXIMUM power setting and 40 s at FULL REHEAT power setting).

To detect and track the targets, use the warning data of the distant radar posts and choose the air alert zone and accomplish the direction proper at the local radar (CP or GP) area. To detect the target, use the radar and radar altimeters of various ranges. If the PPR is cluttered by the local objects and clouds, switch on the respective radar-protection equipment. To make the radio communication stable, use the communication-relay aircraft.

The fighter is led to the alert zone at altitudes of 3000 to 5000 m three to five minutes before the target enters the radar coverage area. The air combat flight regime is determined depending on the speed and flight altitude of the target and its distance to the alert zone. In high visibility conditions (clear weather, lunar night), from a distance of 4 to 6 km, inform the pilot in details on the position of the target so that he can visually detect it if need arises. When the fighter descends to the target attack altitude, the combat control officer must ensure the flight safety. In this case, he must allow for the terrain relief and artificial obstacles, know the flight area safe altitude and inform the pilot about it. He should also continuously check the fighter flight altitude.

Table 19

Distance to alert zone, km	Parameters	Altitude in alert zone, m		
		3000	5000	7000
50	Altitude of flight to alert zone, m	3000	5000	-
	Alert time in zone (V_{IAS} = 500 km/h), min	61	64	-
	Minimum fuel remainder before combat (ρ = 0.845 g/cm^3), kg	5200	5200	-
	Minimum fuel remainder after combat, kg	3100	3100	-
	Landing airfield return altitude, m	3000	3000	-
100	Altitude of flight to alert zone, m	3000	5000	-
	Alert time in zone (V_{IAS} = 500 km/h), min	52	56	-
	Minimum fuel remainder before combat (ρ = 0.845 g/cm^3), kg	5750	5630	-
	Minimum fuel remainder after combat, kg	3650	3530	-
	Landing airfield return altitude, m	3000	5000	-
150	Altitude of flight to alert zone, m	3000	5000	7000
	Alert time in zone (V_{IAS} = 500 km/h), min	43	48	54
	Minimum fuel remainder before combat (ρ = 0.845 g/cm^3), kg	6300	6100	6200
	Minimum fuel remainder after combat, kg	4200	4000	4000
	Landing airfield return altitude, m	3000	5000	5000

If it is necessary for the fighter to descend to the attack altitude upon approaching the target rear hemisphere, before the descent lead it to the target to a distance calculated by the formula:

$$D_{lead} = D_{perm.\ max} + V_{clos} \cdot (t_{atk} + t_{desc}),$$

where t_{atk} stands for the attack time;
t_{desc} stands for time of descent to the attack altitude.

When the fighter is directed to the targets, flying at altitudes of 50 to 1000 m, the LA (MB) airborne radar mode can be used (direction against ground). In this case, the fighter is directed to the target rear hemisphere at an aspect of 1/4 to 0/4 to the target range of 8 to 12 km at a vertical step-up separation of 500 m.

212. When the fighter is directed at low altitudes, make allowance for total corrections for the altimeter readings. To rule out getting of the fighter into the target wake, direct the fighter with a vertical step-down or step-up separation of at least 300 m with respect to the target at an interval of 1 to 2 km.

Depending on the tactical situation, as well as in case of failure of the airborne radar and the fighter carries infrared missiles, use should be made of the heat direction finder.

If, owing to some reason or other, the airborne radar and the heat direction finder cannot be used, direct the fighter to the target visual detection range and attack the target in the φ_o mode.

5.4.3. Direction at High Aspects

213. The procedure of navigational calculations for interception of air targets, as well as those of direction at high aspects with the aid of the automatic direction and control system and PPR is the same as at direction at low aspects.

The peculiarity of direction is the necessity of correction of the fighter lead impact point flight path at the third stage so as to calculate its mean missile launching range at a preset lead.

The specific features of a high aspect attack are the following:

- strict observance of the assigned speed by the pilot;
- short time period of fighter stay in the possible launching zone;
- change of the target aspect before missile launch.

214. Direction of the fighters at assigned permanent aspect of 3/4 to 4/4 from the attack (approach) initiation moment till missile launching at non-maneuvering targets with a purpose of gaining the tactical superiority over the enemy in the air combat.

In calculations, use the formulas:

$$\sin q = \frac{V_{ftr}}{V_{tgt}} \cdot \sin \varphi;$$

$$\theta = 180^{\circ} - (\varphi + q),$$

where φ stands for the target angle (angle formed by fighter speed vector and the direction to the target);

q stands for the fighter angle (angle formed by the target speed vector and the direction to the fighter);

θ stands for the fighter aspect angle;

V_{tgt} stands for the target speed in km/h;

V_{ftr} stands for the fighter speed km/h.

The navigational calculations proper should be performed according to the charts and tables made up beforehand. The example of such a chart is given in Fig. 35. Angle φ should be not more than 50°.

215. Direct the fighter at the assigned aspect with the aid of the automatic control and direction system. Value $\Delta \ell_o$ is set equal to zero. Value ℓ_o is calculated by the formula:

$$\ell_o = \frac{D_{lead} \cdot \sin q}{\sin \theta},$$

where D_{lead} stands for the fighter leading distance in km.

The length of the closure line (ℓ_o) should ensure correction of the errors of direction, target detection, lock-on and aiming.

If the direction task is solved unsteadily, vary parameters ℓ_o, R, and in some cases the direction of turn, to obtain a normal run of solution.

At the third stage of direction, the combat control officer should inform the pilot on the aspect of attack, target position with respect to the fighter and the target flight parameters (course, speed, altitude). If necessary, give the pilot a command to change over the scanning zone of the airborne radar to the respective direction.

216. At the closing stage, the relation between the fighter flight speed and the target speed should be as follows:

- in the front-cone attack, at relative bearing of up to 45°, not less than 0.8; not less than 1.0 at relative bearing of up to 45 to 60° and not less than 1.2 at relative bearing of up to 60 to 90°;
- in the rear-cone attack, not less than 1.2 at any aspect.

If the distance to the assigned interception line as well as the depth of the radar field created by the ground radars, tactical situation, flight speed and altitude of the target, time at the disposal of the pilot for detection and aiming make it possible, the fighter should gain as greater superiority in speed as possible over the target flight speed.

When launching an attack at altitudes, close to the aircraft non-reheat ceiling, at a vertical step-down separation with respect to the target of more than 1000 m and a flight speed close to the maximum one for the given flight conditions, some 10 to 15 s before entering the aiming zoom, the combat control officer must given the pilot a command to select the engine reheat power.

5.4.4. Direction to High-Altitude and High-Speed Targets

217. Direct the fighter to high-altitude and high-speed targets in compliance with the flight profiles shown in Figs 23 through 32.

The flight for the air combat at the supersonic airspeeds and maximum maneuvering altitude is characterized by the following features:

- stratospheric flight of the fighter is performed only with the engines running at reheat power, that significantly increases the fuel consumption per kilometre and limits the aircraft time in the air;
- rapid closure with the target in the process of direction and attack, especially in the front-cone attack;
- degradation of the aircraft maneuverability in stratosphere;

- entry into the dynamic altitudes at high elevations over the target;

- restricted pilot's actions when the high-altitude outfit is put on;

- increased requirements are imposed on the work of the combat control officer on fighter control dictated by the necessity of obtaining the maximum precise direction, that is especially true for the navigational calculations proper and observance of the methodical sequence.

5.4.5. Direction of Fighter when Attacking Target with Use of Heat Direction Finder

218. The procedure of the navigational calculations as well as performance of direction of the fighter when attacking the target with the use of the heat direction finder are the same as in direction of the fighter when attacking the target with the use of the airborne radar. However, while performing the direction, take into account the following peculiarities:

- the relative bearing of the sun (moon) should be more than $\pm 30^{\circ}$;

- direction to the non-reheat targets should be performed only into the rear hemisphere at an aspect not more than 3/4;

- detection and lock-on of the target against cumulus clouds are seriously hampered;

- the field of vision of the ТП-26Ш1 heat direction finder in the "T-I", "T-III" and "T-φ_{oI}" modes sizes to 4° up and 9° down in elevation. Owing to this, the optimum vertical step-down (step-up) separation of the fighter with respect to the target while attacking from below is 500 m and while attacking from above, 1000 m;

- direction to the reheat targets can be performed both into the rear hemisphere and into the front hemisphere.

5.4.6. Direction under Conditions of ECM to Ground and Airborne Radars

219. To direct the fighter under all kinds of ground radar jamming, the combat control officer should use all the data on the targets both from the local radars of all ranges and from the radar posts, especially those located aside from the target flight line.

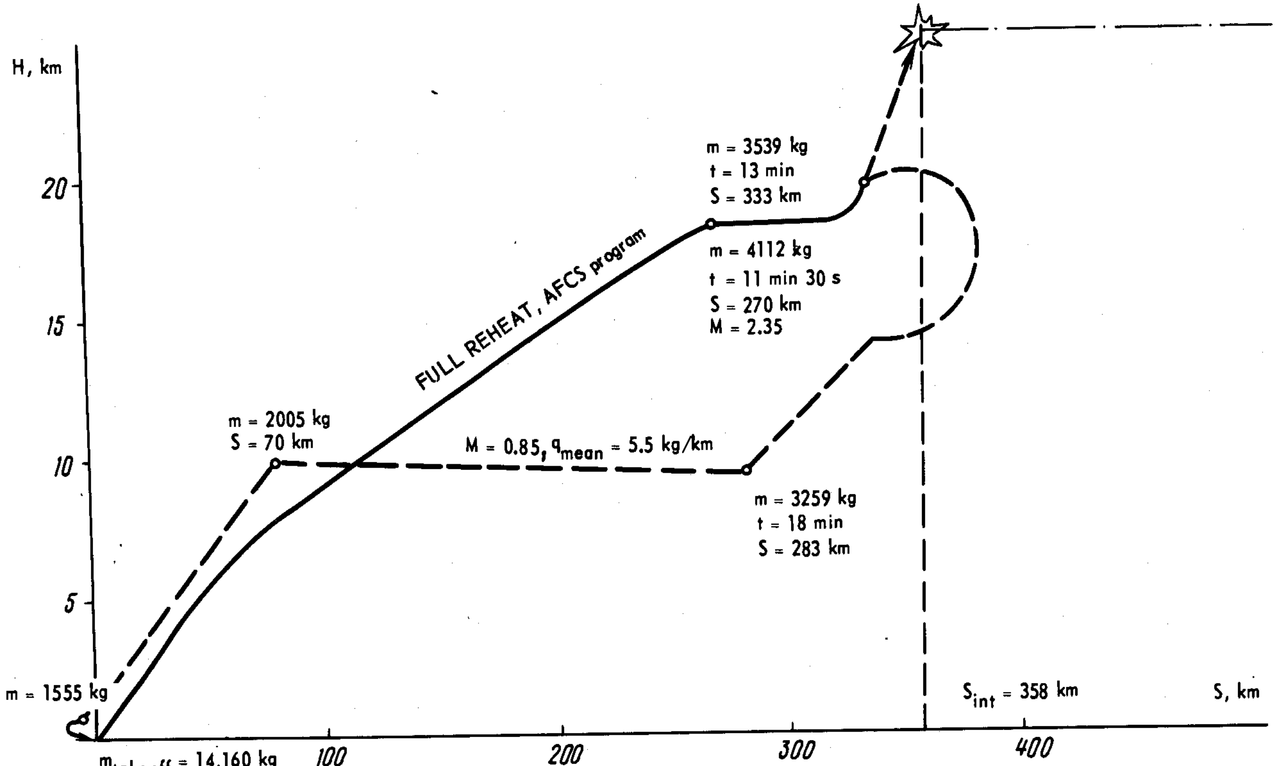


FIG. 23. PROFILE OF FLIGHT FOR AIR COMBAT ACCORDING TO AFCS PROGRAM AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING

(reheat power setting, H_{ftr} = 18,000 m, V_{ftr} = 2500 km/h, forward-cone attack, $H_{tgt} \leqslant$ 27,000 m, V_{tgt} = 3000 km/h)

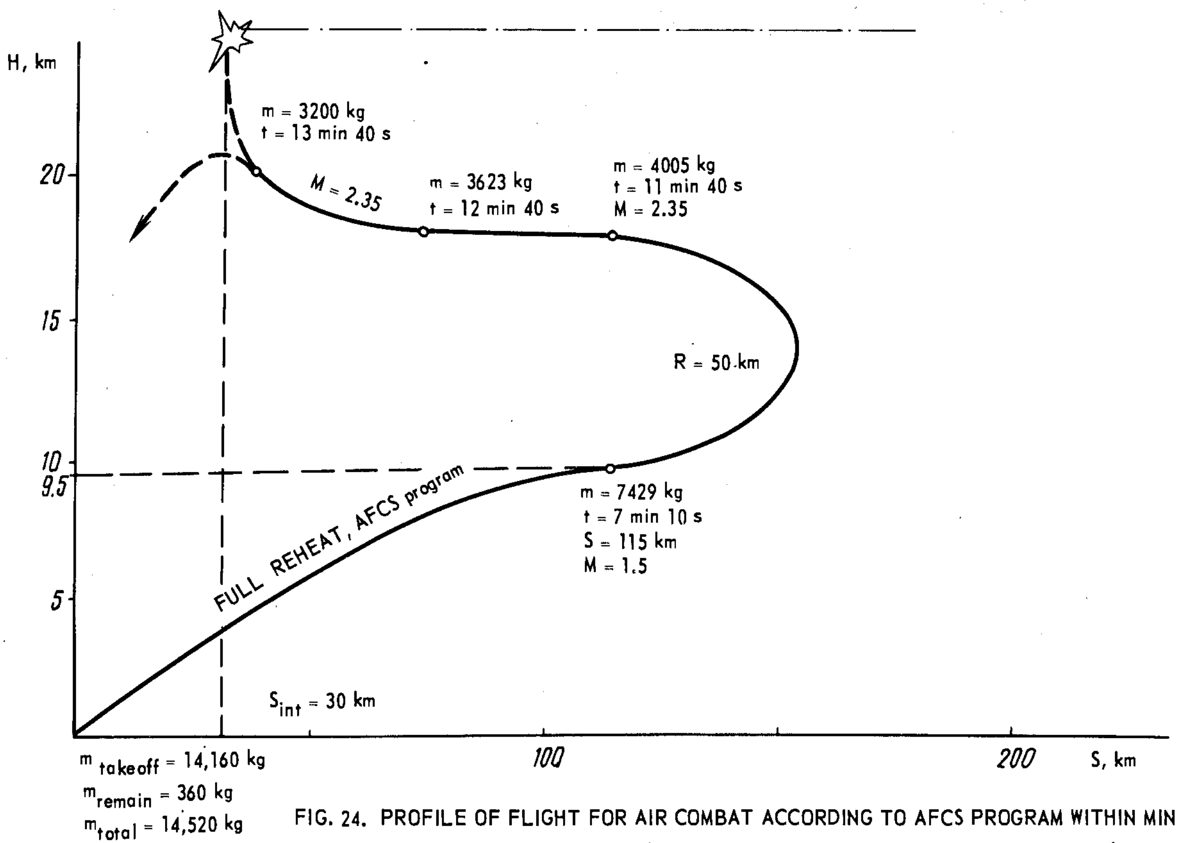


FIG. 24. PROFILE OF FLIGHT FOR AIR COMBAT ACCORDING TO AFCS PROGRAM WITHIN MINIMUM TIME
(reheat power setting, H_{ftr} = 18,000 m, V_{ftr} = 2500 km/h, rear-cone attack, $H_{tgt} \leqslant$ 27,000 m, $V_{tgt} \leqslant$ 2000 km/h)

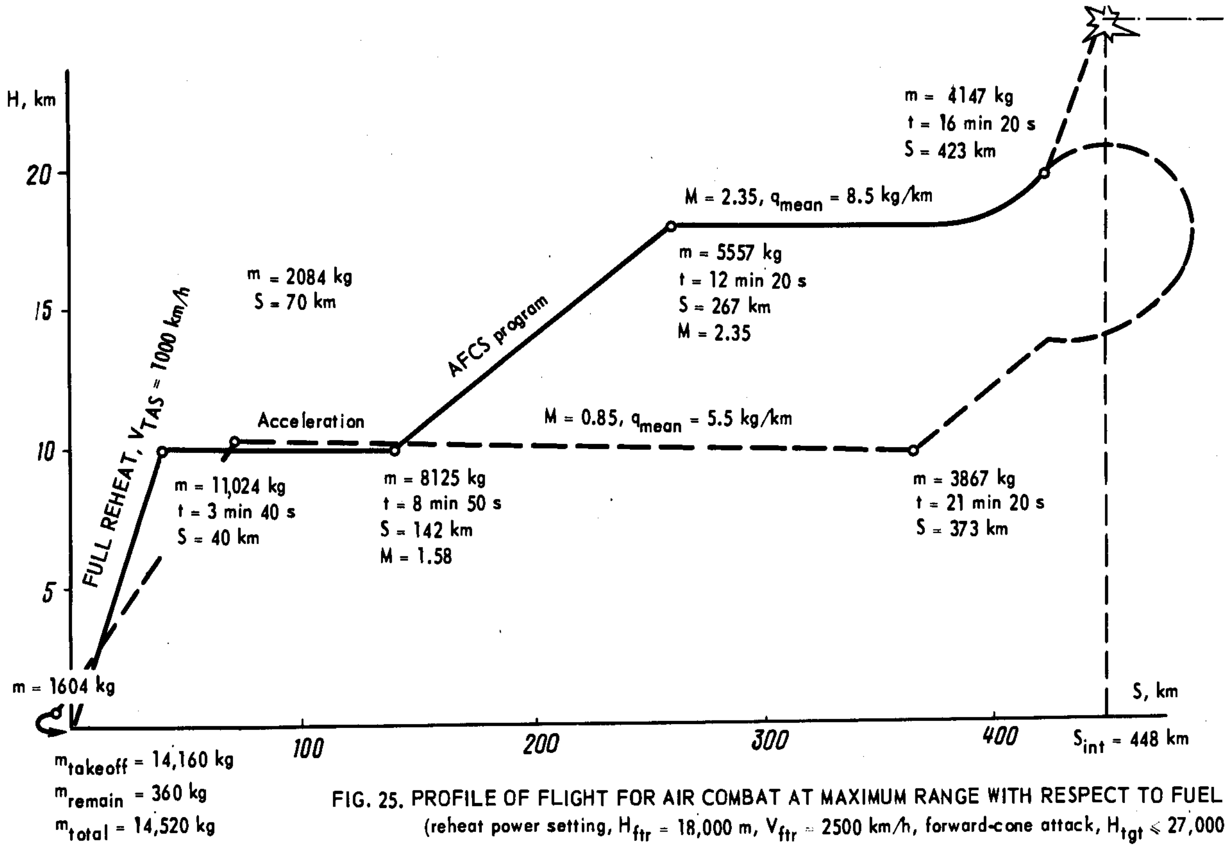


FIG. 25. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING (reheat power setting, H_{ftr} = 18,000 m, V_{ftr} = 2500 km/h, forward-cone attack, $H_{tgt} \leq$ 27,000 m, $V_{tgt} \leq$ 3000 km/h)

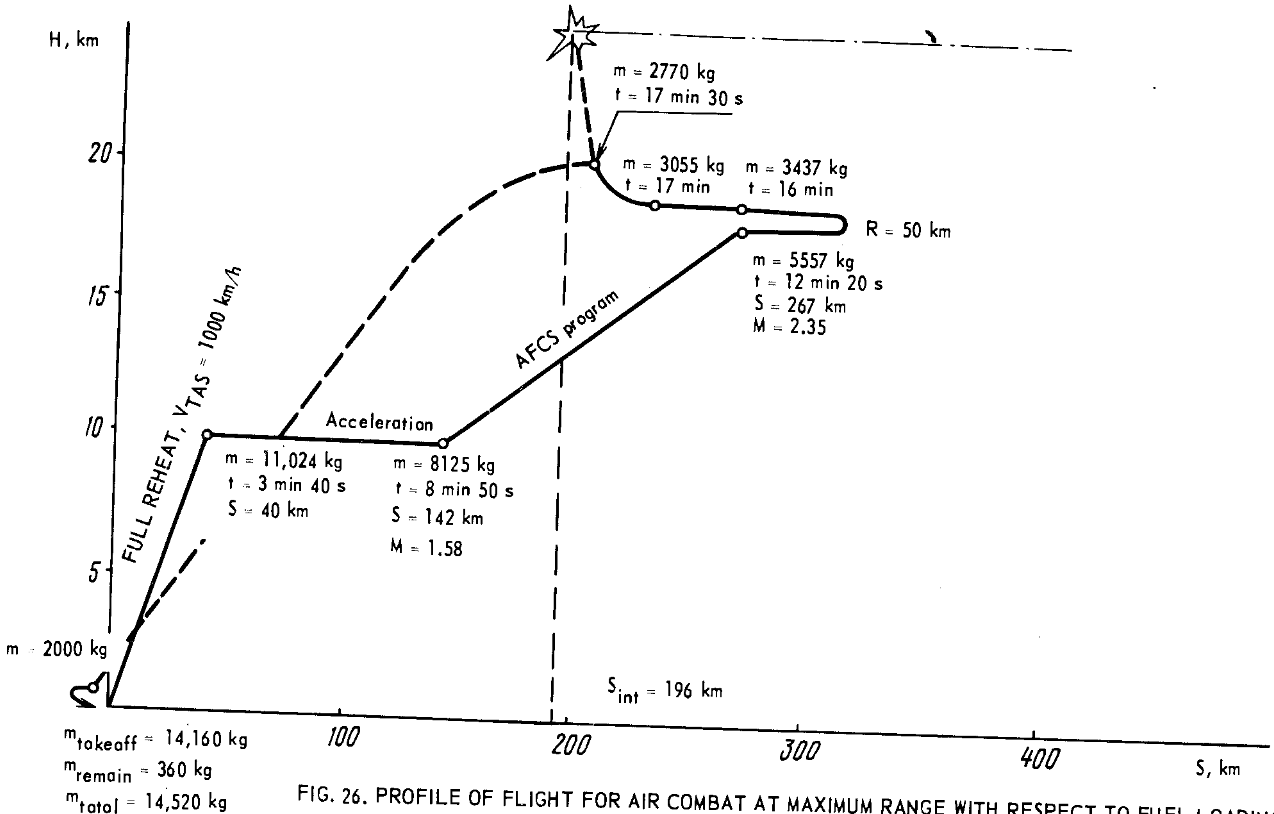


FIG. 26. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING (reheat power setting, H_{ftr} = 18,000 m, V_{ftr} = 2500 km/h, rear-cone attack, $H_{tgt} \leqslant$ 27,000 m, $V_{tgt} \leqslant$ 2000 km/h)

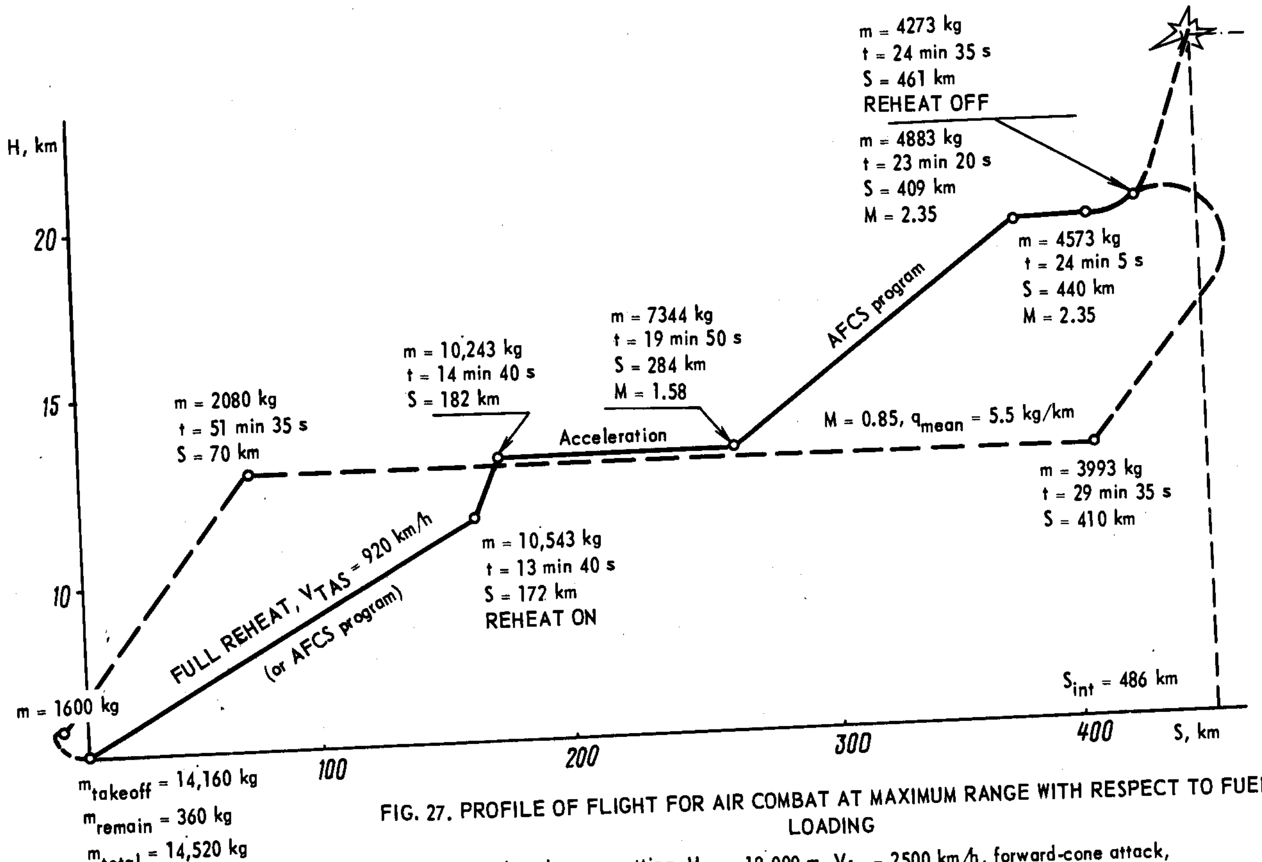


FIG. 27. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING

(combined power setting, H_{ftr} = 18,000 m, V_{ftr} = 2500 km/h, forward-cone attack, $H_{tgt} \leq$ 27,000 m, $V_{tgt} \leq$ 3000 km/h)

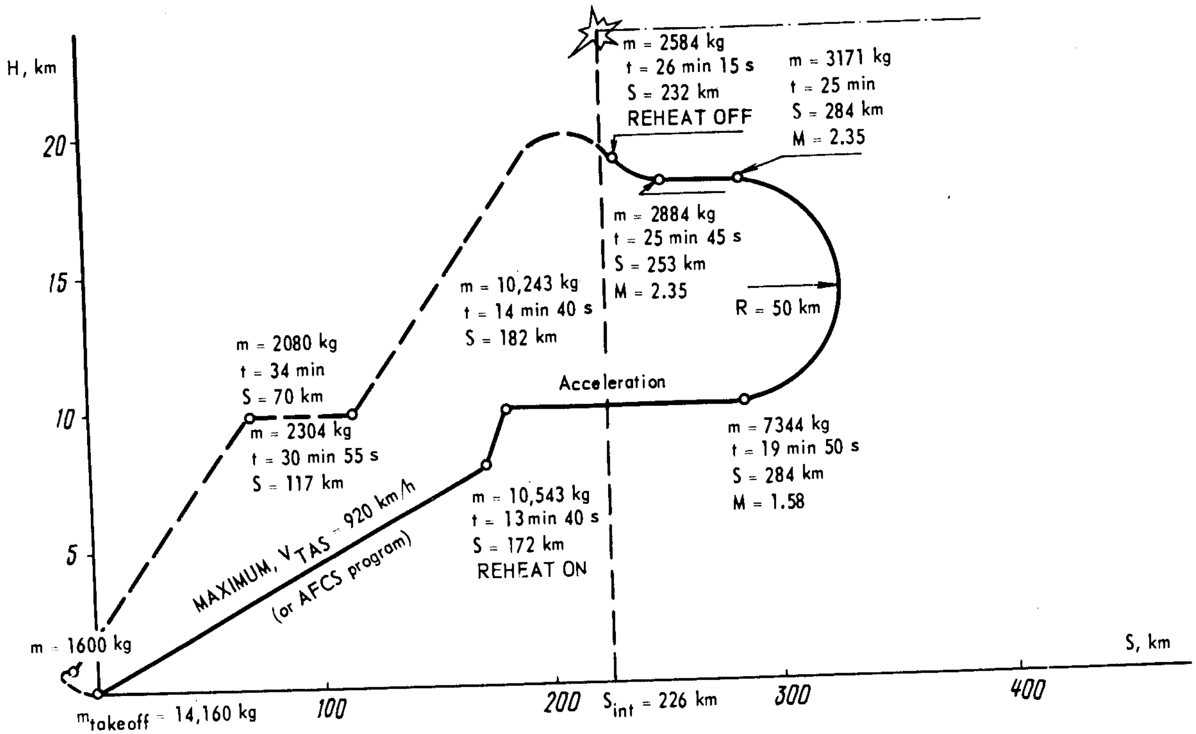


FIG. 28. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING

(combined power setting, H_{ftr} = 18,000 m, V_{ftr} = 2500 km/h, rear-cone attack, $H_{tgt} \leq$ 27,000 m, $V_{tgt} \leq$ 2000 km/h)

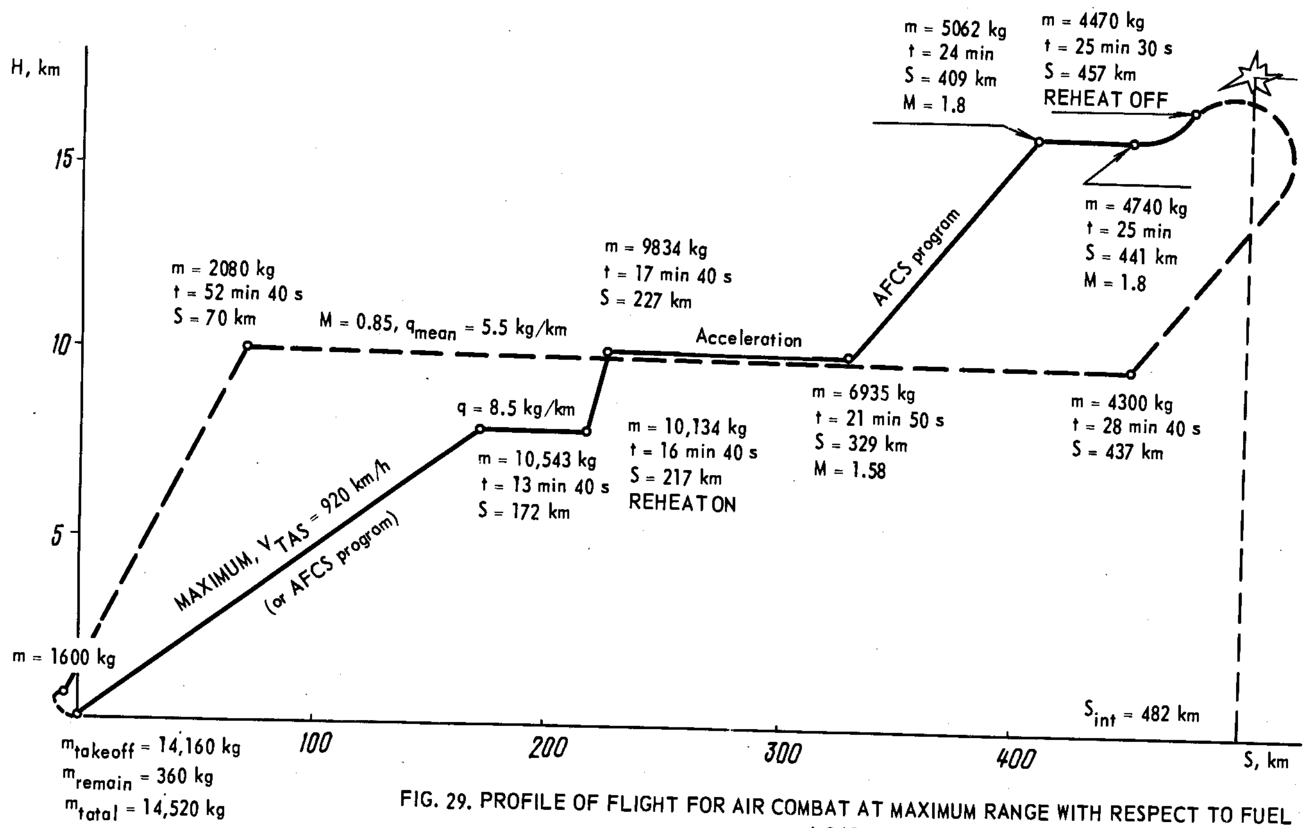


FIG. 29. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING

(cruising power setting, H_{ftr} = 16,000 m, V_{ftr} = 1900 km/h, forward-cone attack)

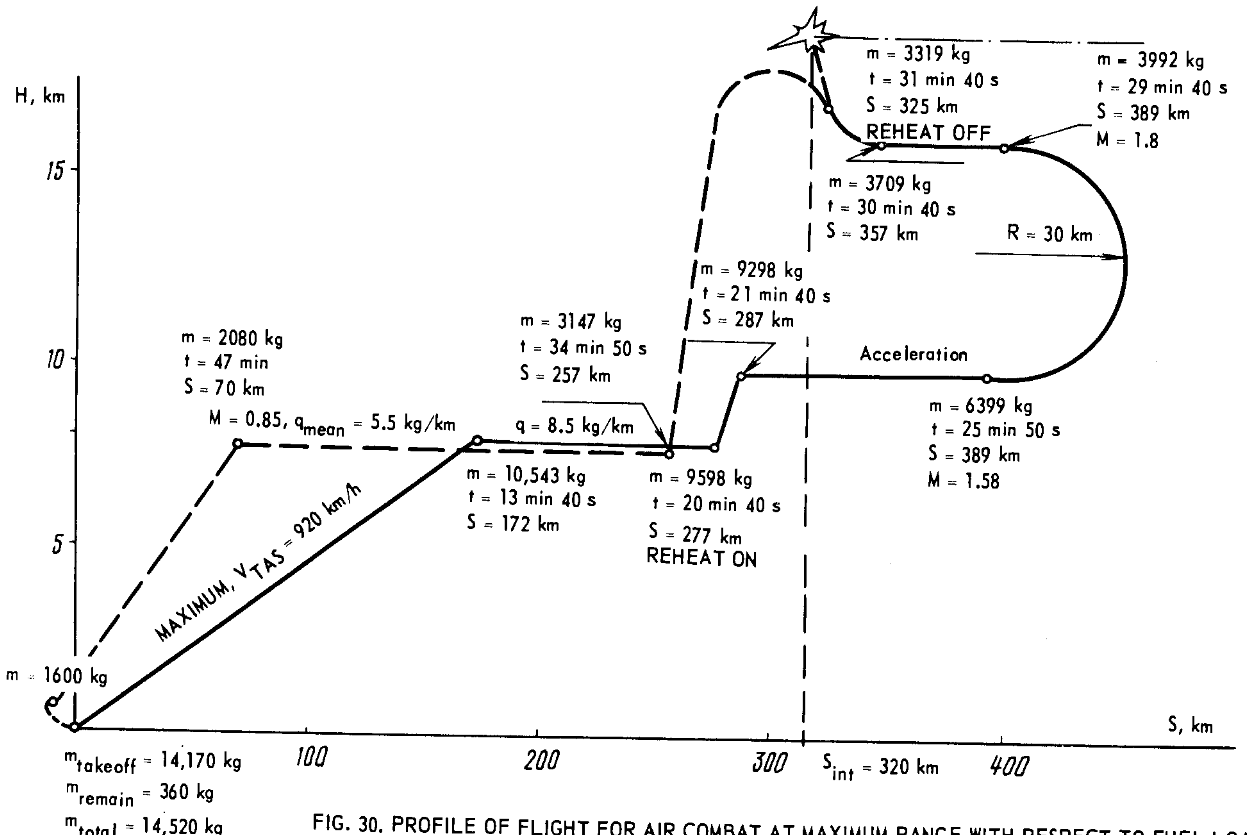


FIG. 30. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING (cruising power setting, H_{ftr} = 16,000 m, V_{ftr} = 1900 km/h, rear-cone attack)

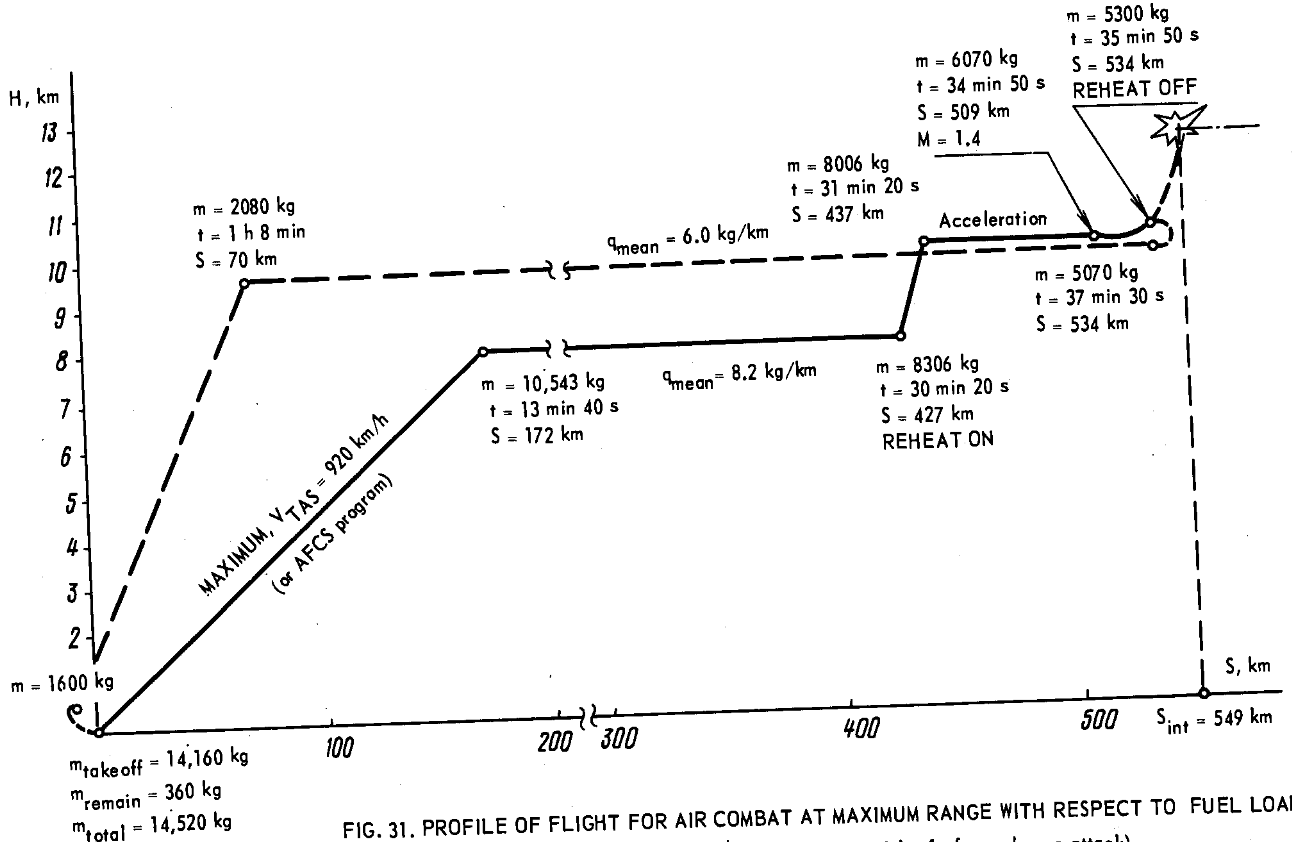


FIG. 31. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING
(cruising power setting, H_{ftr} = 10,000 m, V_{ftr} = 1500 km/h, forward-cone attack)

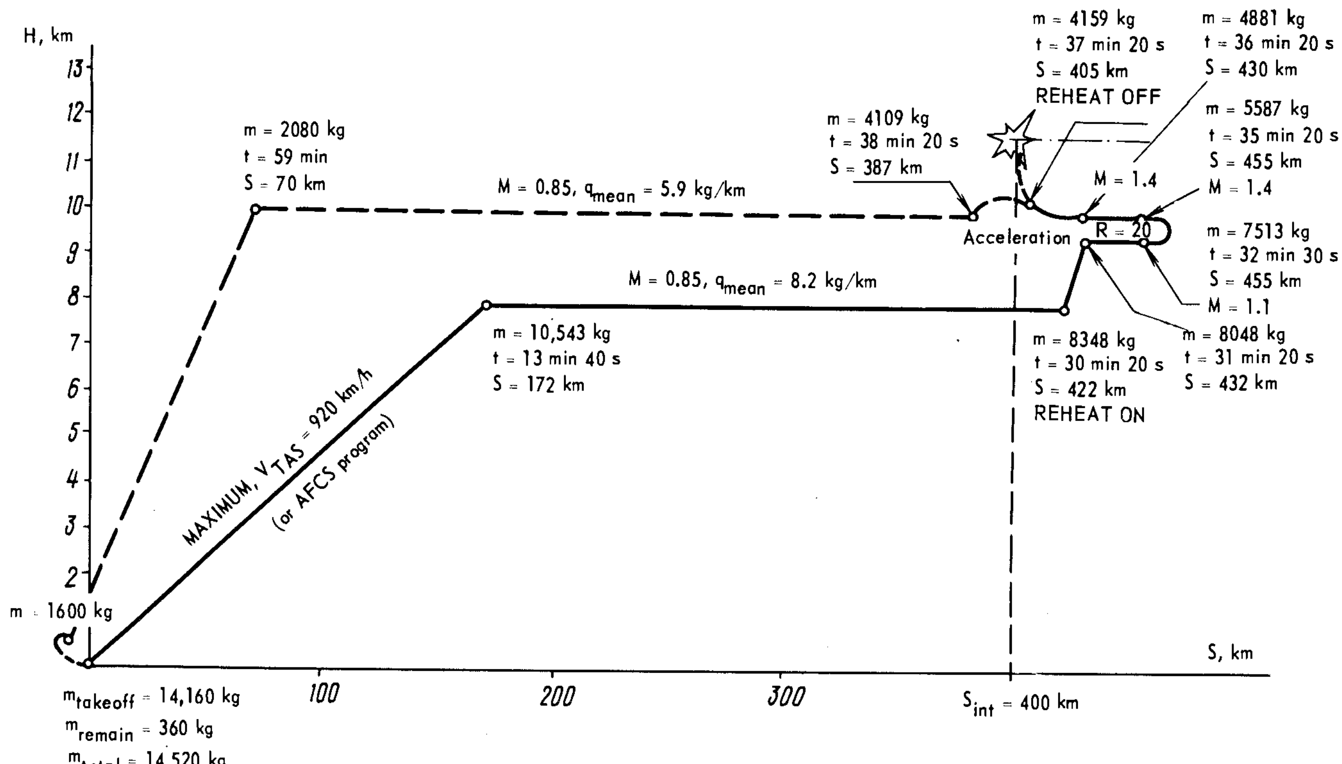


FIG. 32. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING

(cruising power setting, H_{ftr} = 10,000 m, V_{ftr} = 1500 km/h, rear-cone attack)

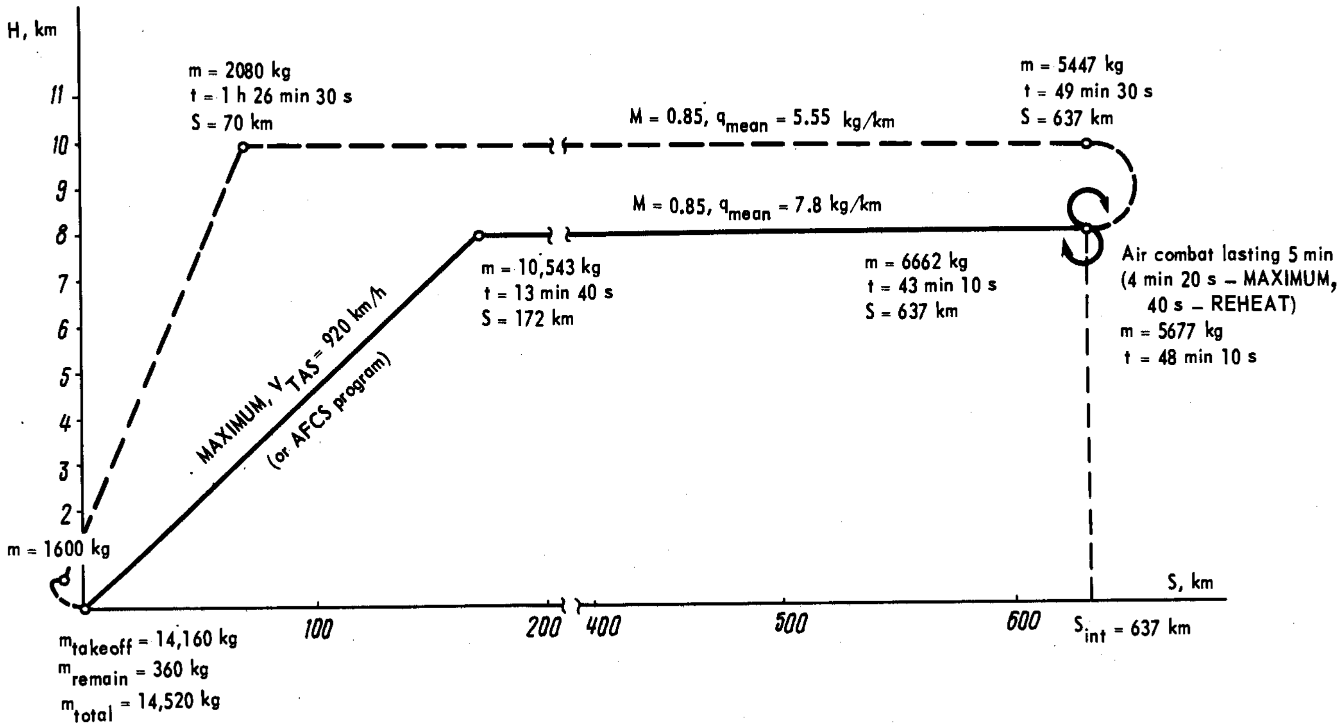


FIG. 33. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING

(cruising power setting, H_{ftr} = 8000 m, V_{ftr} = 950 km/h)

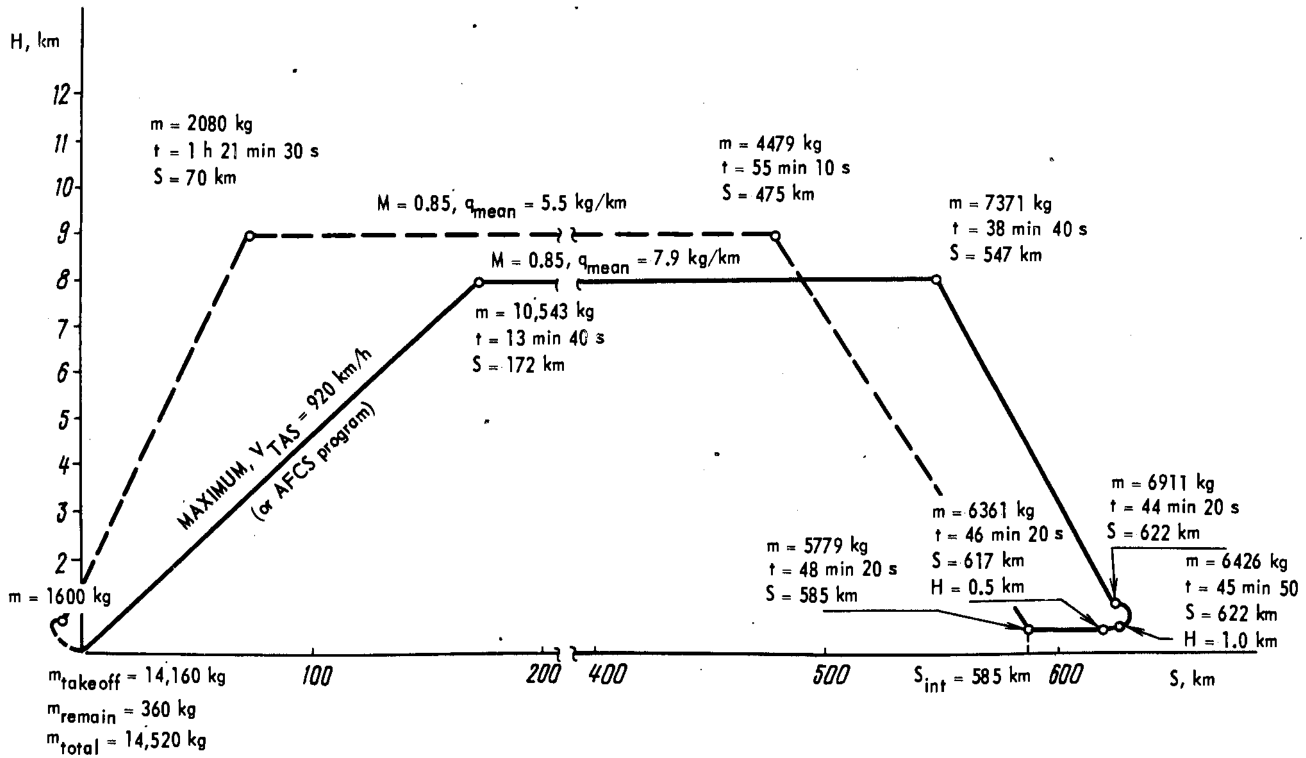


FIG. 34. PROFILE OF FLIGHT FOR AIR COMBAT AT MAXIMUM RANGE WITH RESPECT TO FUEL LOADING (cruising power setting, H_{ftr} = 500 m, V_{ftr} = 960 km/h, rear-cone attack, H_{tgt} = 800 m, V_{tgt} = 800 km/h)

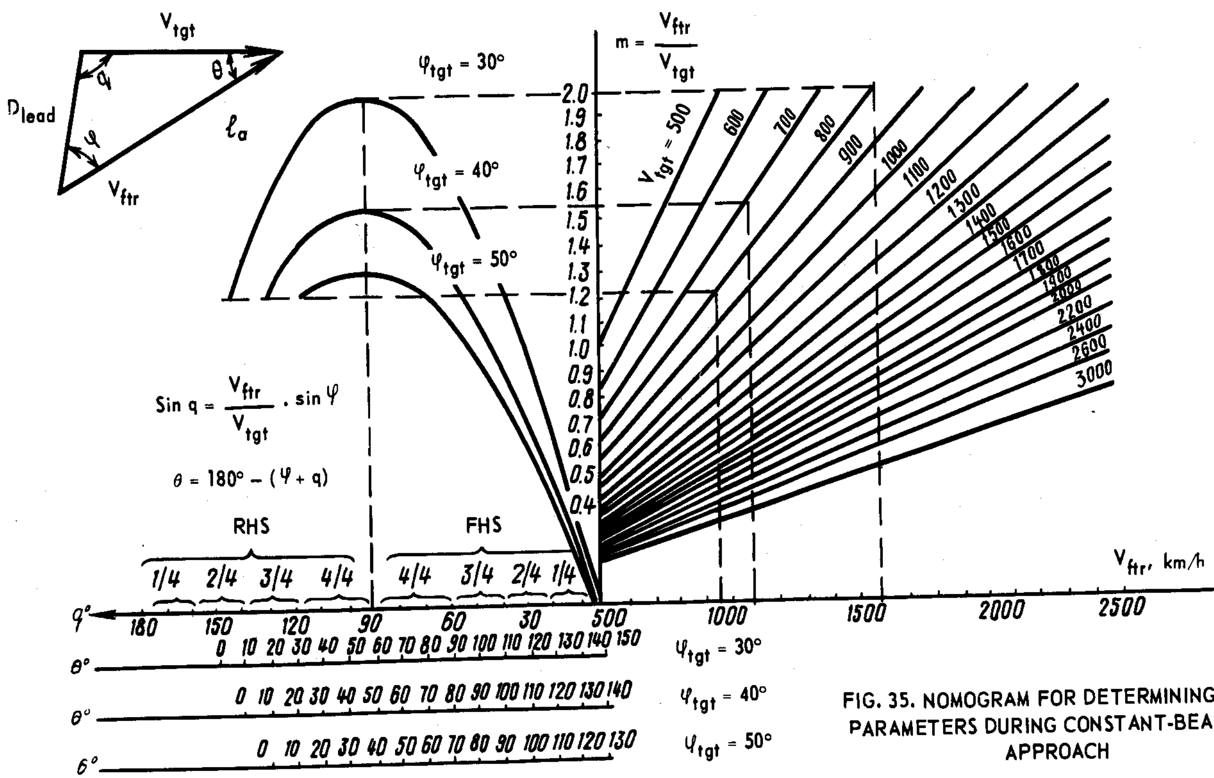


FIG. 35. NOMOGRAM FOR DETERMINING ATTACK PARAMETERS DURING CONSTANT-BEARING APPROACH

When the direction is carried out by means of the radar PPR, the crew of the control (guidance) post should use all protective means against the radar active and passive jamming. If it is impossible to perform direction with the help of the radar plan-position repeater due to jamming, change over to direction in response to the secondary radar information from the distant radar posts or from the plotting board (electronic board) which receives information from all sources (data of the local radars, warning network, surveillance posts, radar post aircraft).

220. Direct the fighters to the active jammer by a three-point or triangular method.

In a three-point direction the combat control officer should:

- estimate the general flight direction of the active jammer against the cluttered sector width on the plan-position repeater. If the cluttered sector width grows on the plan-position repeater, the jammer flies to the radar and vice versa;

- approximately estimate distance to the jammer against the cluttered sector width on the plan-position repeater to determine possibility of destruction with respect to the fuel reserve;

- determine the jammer azimuth with reference to the cluttered sector axis;

- for performing the target search with the use of the airborne radar, bring the fighter from the direction reverse to the cluttered sector moving direction at an interval of 10 to 15 km off the fighter axis at a course, parallel to the clutter axis;

- give the pilot the command to shift the airborne radar scanning area in the direction of the cluttered sector axis.

As the cluttered sector position is changed, the combat control officer should give a command to maintain the flight direction parallel to the sector axis. To render interception more probable, assign several fighters for one target-jammer and direct them at different flight levels. Determine the position of fighters under the jamming conditions with the help of the active response and identification, as well as by requesting the distance and azimuth from the pilots with the use of the short-range radio navigation and landing system.

As the pilot detects the target under the jamming conditions with the help of the airborne radar, heat direction finder or as he is lead out onto the visual contact with the target, the combat control officer should transmit the target position and range to the fighter systems both over the radio and with the help of the automated direction equipment over the radio link equipment.

In this case, the combat control officer should use all types of the available ground radars to transmit information continuously. He should pay special attention to inform the pilot on the target altitude, checking the information with all types of radar altimeters.

If the direction channel is jammed and it is impossible to receive the commands from the control post, the pilot changes over to the stand-by communication channels (USW, UHF band, over RLE and ADF) according to the preset schedule.

If communication with the pilot is lost, the receivers are monitored in these channels at the control (guidance) post. Under the conditions of ECM to radio communication the combat control officer should:

- change over to the stand-by communication channels according to the preset schedule;
- use the homing radio stations in the microphone mode to transmit the direction commands;
- transmit the direction commands with the help of the АРЛ radio link equipment;
- periodically (in the clear) inform the pilot on the target location, its course and flight speed, advise the pilot the course and altitude, flight time on the advised course and the direction of the subsequent turn.

To fight the airborne radar jamming, the pilot should adequately use the antijamming technical means together with the tactical methods of direction. The tactical methods include the following:

- surprise attack (is attained by cutting in the airborne radar for illumination at minimum ranges);
- leading of the fighter for attacking the target into the front hemisphere;
- leading of the fighter for attacking the target at a high aspect and with maximum vertical step-down (step-up) separation.

5.4.7. Direction with Transfer (Taking-Over) of Control to Cooperating Control (Direction) Post

221. When organizing the combat actions for destruction of the air targets, in advance make provision for transfer of control of the fighters to the control (direction) post of the cooperating units and formations to create conditions for actions of the fighters at maximum ranges, ensuring their landing on the takeoff or alternate airfield.

Fighter control is transferred at the respective lines determined depending on the combat actions area and location of the fighter air units in this area, as well as on the potential flight directions and altitudes of the air enemy and capabilities of control facilities.

The process of control transfer should not interrupt the progress of the direction task solving. Owing to this, it is expedient to transfer the control on the straight leg (at the first stage of direction).

Fighters control may be transferred to the cooperating control (direction) post as follows:

- over the communication channels in the ground control networks;
- over the communication channels in the fighters control network with the help of the pilot.

222. If need arises to transfer control, the control post, directing the fighters in its area, informs the cooperating control (direction) post on the transfer over the available communication channels and transmits the following data to it:

- the number, location and performance of the air target to which the fighters are directed;
- the location, strength and call signs of the friendly fighters;
- the number of the channel for communication with the friendly fighters;
- the fuel remainder of the fighters;
- the landing airfield;
- the intentions on the fighters direction.

While taking over the control, the cooperating control (direction) post should detect the fighters, establish communication with them and, on making sure that it is possible to control them with respect to the fuel reserve, report the transferring control post the control take-over.

On making sure that the cooperating control (direction) post is ready for taking over the control, the control post, transferring the fighters control, gives his fighters the pre-established signal to inform them on carrying out the control from the cooperating control (direction) post.

Control is considered transferred upon obtaining confirmation from the pilot on stable two-way communication with the cooperating control (direction) post and on the fact that the latter controls the fighters. In some cases the transfer of the fighter control can be followed by a temporary loss of the two-way communication with it. In these cases, the fighter is advised the assigned course flight time, flight altitude, line and time estimated for establishing communication with the control (direction) post that takes over control over the fighter, as well as the call sign of this control (direction) post. If on a lapse of the said time communication with the cooperating control post is not established, the pilot should fly back, restore communication with his control post and act according to its instructions.

223. In cases when it is impossible to use the communication channels of the ground control facilities, control can be transferred to the cooperating control (direction) post right with the help of the pilot over the communication channels in the fighter control network. In this case, the control (direction) post, which transfers the control, gives the call sign and the communication channel of the cooperating control post to the pilot before takeoff or when approaching the control transfer line. At the control transfer line, the control (direction) post, transferring the control, gives the pilot a command to establish communication with the cooperating control (direction) post. The pilot reports his location and location of the target to which he is directed to the cooperating control (direction) post. Upon detection of the fighter, the cooperating control (direction) post requests the required data from the pilot, takes over the control and continues direction.

224. In all cases when the fighter control is taken over, the combat control officer of the control post taking the control checks the fuel remainder on the aircraft and estimates possibility of landing of the aircraft at one of the assigned airfields. The combat mission accomplished, with the fuel remainder making it possible to land at the departure airfield, the combat control officer of the cooperating control (direction)

post transfers the fighter control to the control post of this airfield. Otherwise, the combat control officer advises the pilot the data of the alternate airfield and brings the fighter into the estimated point of descent for landing approach. The time and the fighter landing airfield are reported to the main control post.

5.5. SINGLE AND FORMATION AIR COMBAT CONTROL

225. The single and formation air combat of the fighters with the enemy aircraft are controlled from the ground and in the air by the formation commanders. In this case, the formation commander controls the fighters within the visual contact of the formation and enemy aircraft, while the combat control officer controls the fighters on the basis of the commander intentions when the enemy is out of the visual contact.

Prompt and active actions of the combat control officer during the air combat control make it possible to considerably influence the issue of the combat.

The air combat is controlled from the control post with the purpose of:

- bringing the fighters into a tactically advantageous initial attack position;
- delivery of continuous information for the formation commander on the air situation in the combat area and its change;
- delivery of information to the fighters on actions of the air enemy in the combat area and giving the commands on execution of an expedient maneuver for taking up a tactically advantageous position or evading the enemy attack;
- carrying out a continuous check over the actions of the friendly fighters and rendering an assistance to them in restoring the combat formation.

The ground radar with the best resolving power in determination of the target coordinates and the radar altimeter should be detailed for the combat control officer.

In the process of the combat, the combat control officer should know the dispositions of the friendly and enemy aircraft at any time and visualize their spatial attitude. When the air combat is conducted at low altitudes, the formation commander and the combat control officer should allow for an enemy surprise attack threat.

To rule out a potential stealthy build-up of efforts by the enemy, use the information of the warning network and distant radar posts and predict the enemy flight route in case of the enemy data inflow stops to come. The combat control officer should bring the fighters to the group air target with regard for the enemy combat formation. The combat formation of the enemy can include a number of tactical groups: a cover group, an air defence means neutralization group and strike groups. The cover group includes the fighters with the best maneuvering characteristics. The air defence means neutralization group includes the most maneuvering fighters-bombers with a minimum combat load. The strike group includes the fighters-bombers with normal or increased combat load. Maneuvering capabilities of the aircraft of this group are limited until the combat load is used. When conducting the combat actions against the group air target, the main task is to destroy the aircraft of the strike groups or make them release the combat load prematurely. This task can be fulfilled if the first attack is a rapid and surprise attack. Depending on the enemy combat formation, direct the fighters to the enemy strike group from the side free from the cover fighters, at low altitudes (if possible) with a subsequent climb in the process of attack. Break off from the attack at a speed, close to the maximum one with the turn to the direction where the attack by the fighters of the enemy strike and cover groups is surely ruled out.

The combat control officer should advise a tactically advantageous direction and altitude of breaking off from the attack. If the tactical situation makes it impossible to launch a surprise attack, direct a part of the fighters to the cover group, and the main part, to the strike group. It is necessary to attack the strike group and the cover group simultaneously. In this case, the attack launched against the cover fighters draws the enemy from execution of the main task.

It is necessary to use the defensive maneuvers in the air combat as well.

If the situation makes it possible, give the pilot a command to evade in the direction of sun, moon, earth, into the clouds or some other sources of jamming, interfering with the fighter detection, missile launch and the missile homing as well.

As the fighter breaks off from the attack, the combat control officer should ensure safety against a surprise attack by the enemy until the fighter lands at the friendly airfield.

5.6. SAFETY MEASURES TO BE OBSERVED IN AIR COMBAT CONTROL

226. The following factors ensure safety of the air combat:

- knowledge of the air combat flight regimes, established aircraft limitations, safe altitudes in the combat area, procedure of transition to the stand-by communication channels by the pilots and the combat control officers;
- teamwork of the control (direction) post crew;
- prompt information on air situation;
- constant check of the flight time and fuel remainder on the aircraft;
- timely information of the antiaircraft missile troops on actions of the fighters and organization of cooperation with them;
- continuous check of the weather conditions in the area of the departure airfield, alternate airfields, as well as on the flight routes for the air combat;
- timely taken decision on landing the fighters at the alternate airfield in case the weather runs adverse in the area of the departure airfield (or it cannot be used);
- keeping safe distance among the fighters in the airfield area and on the flight routes for the air combat.

When the fighters are directed to the target, the combat control officer should know the actual step-up (step-down) vertical separation of the target with respect to the fighter and inform the pilot about it. He should timely warn the pilot about initiation of the maneuver by the target.

When attacking the air targets, the combat control officer should ensure the step-down (step-up) vertical separation of the fighter with respect to the target of not less than 300 m at low altitudes, 500 m, at medium and high altitudes and not less than 1000 m in stratosphere.

227. To ensure the flight safety, the combat control officer should discontinue the flight mission in the following cases:

- absence of stable two-way radio communication with the pilot;
- failure of the identification system of the aircraft;
- failure of the direction radar;
- upon getting the pilot's report on icing of the aircraft, its failure or poor state of health;

- aircraft minimum fuel remainder needed for flying back to the landing airfield;

- as the target or fighter leaves the detection zone of the direction radar, when no control transfer to the other control (direction) post is planned in the mission;

- in all cases by the command of the flight control officer.

228. In the process of control and direction, the combat control officer is not allowed:

- to advise the pilot the flight speed less than the maneuvering one or more than the maximum permissible speed for the given altitude, roll exceeding the permissible one, as well as the altitude lower than the safe one in the particular flight area or not corresponding to the assigned operating mode of the engines;

- to give a command to descend without specifying the recovery altitude and advise the pilot a vertical rate of descent higher than the permissible one for the given flight altitude;

- to allow the fighter to approach the target to a range less than the minimum permissible one, specified by the conditions of the exercise performed by the pilot;

- to allow the radar mark of the fighter and that of the foreign target to converge in one point on the plan-position repeater when the difference in their flight altitudes is less than the safe one for the given altitude.

In all cases when ensuring the flight safety, the actions of the combat control officer should be prompt, decisive and purposeful, arising no doubt on the part of the crew members.

5.7. DIRECTION OF FIGHTER МиГ-25ПД (МиГ-25ПДС) TO AIR TARGETS WITH USE OF INSTRUMENT DIRECTION EQUIPMENT

229. The АПН instrument direction equipment (IDE) is designed for automated direction of the fighters to the air targets as well as for generation of the target designation commands for the antennas of the airborne radar sights. The generated control and target designation commands are automatically transmitted to the fighters systems with the help of the radio link equipment.

The instrument direction equipment solves the direction task within the limits of:

- $\pm$600 km (for rectangular coordinates) on axes X, Y;
- 0 to 360° in azimuth;
- 500 to 30,000 m in altitude;
- 600 to 3600 km/h in speed;
- 0 to 25 min in the fighter flight time till the beginning of acceleration (τ_o);
- 0 to 30 min in flight time of the target and fighter (τ_{tgt}, τ_{ftr});
- 0 to 15 min in the fighter flight time at the final speed (τ_{final});
- by referring to the track parameters in the MANEUVER (MAHEBP) direction method: the straight leg length at the first stage (S_{str}), from 0 to 500 km; the maximum turn angle, from 0 to 315°; the fighter turn radius (R_o), from 10 to 80 km; the straight leg length after the turn (ℓ_o), from 0 to 120 km; the direction length ($\Delta\ell_o$), from 0 to 30 km; the aspect (Θ), from 0 $\pm$ 180°;
- by the target and fighter relative position commands: the fighter-target ($D_{ftr-tgt}$) distance of 0 to 100 km; the fighter-target azimuth ($\beta_{ftr-tgt}$) of 0 to 360°; the fighter-target elevation ($\varepsilon_{ftr-tgt}$) of 0 $\pm$ 42°; the fighter-target closure speed (V_{clos}) of 0 to 7200 km/h; the fighter vertical speed (V_H), of 0 $\pm$ 360 m/s.

The computer solves the direction task by three methods: "pursuit", "interception" and "turn".

The trajectory of the "turn" method is determined by the following parameters:

- the fighter-target distance at the end of direction ($\Delta\ell_o$);
- the aspect angle (Θ);
- the target approach straight leg length (ℓ_o);
- the turn radius (R_o).

Direction by the "turn" method is divided into three stages:

- the first stage is a straight leg from the direction initial point to the roll-in point (S_{str});
- the second stage is a turn leg (S_R);
- the third stage is a target approach leg after the turn ($\ell_o - \Delta\ell_o$).

Practically the "interception" method includes only one stage (target approach), since the direction trajectory is straight. The "pursuit" method is not divided into stages.

The "turn" method ensures the direction of the fighter to the target on the preset line at the required aspect angle (Θ)

and leading of the fighter to the selected range at the assigned vertical step-down (step-up) separation with respect to the target. This method is considered to be the main one.

230. The IDE-assisted preliminary navigational computations are made with the PREPARATION (ПОДГОТОВКА) mode cut in. The data on the target and fighter, as well as the passive time (time for engine starting, taxying out and bringing the fighter to the initial direction point) are introduced into the СРП computer. The target destruction line position marker illuminates on the УД display screen.

Prior to directing, the combat control officer should check the selector switches on the СРП computer for being set to the following positions:

- the LAZUR-M - LAZUR, to the LAZUR-M position;
- the V_{final} - AUTO - V_{clos} ($V_к$ - АВТ. - $V_{сбл}$), to the V_{final} position;
- the H_{preset} - V_H ($H_{зад}$ - V_H), to the H_{preset} position;
- the DIRECTION - REDIRECTION (НАВЕДЕНИЕ - ПЕРЕНАЦЕЛИВАНИЕ), to the DIRECTION position;
- the D - Dx5, to the Dx5 position;
- the RHS - FHS (ЗАДНЯЯ - ПЕРЕДНЯЯ), to the position corresponding to the target attack selected hemisphere;
- the AUTO INCL - OFF (АВТ. НАК. - ВЫКЛ.), to the AUTO INCL position;
- the function selector switches, to the NORMAL SOLUTION (НОРМАЛЬНОЕ РЕШЕНИЕ) position;
- the flight conditions selector switch, to the position corresponding to the selected flight conditions.

231. For direction the initial data are as follows:

- the coordinate system;
- the initial point of direction;
- the direction method;
- the direction parameters.

The coordinate system is selected depending on the information source. When the target data arrive from the local radars, direction is performed in the polar coordinate system (azimuth, range). If the target data arrive from the distant radar posts via the data removing and transmitting equipment, direction is performed in the rectangular coordinate system.

The direction parameters are selected by the combat control officer depending on the target flying speed and altitude and the direction method.

The initial direction parameters, introduced into the СРП computer by the combat control officer for solving the direction task, are as follows:

- the turn radius (R_o);
- the target range at the end of direction ($\Delta \ell_o$);
- the straight leg length after the turn (ℓ_o);
- the aspect angle (Θ);
- the fighter assigned initial and final flight speeds (V_o and V_{final});
- the flying time before start of acceleration (τ_o);
- the fighter flying time at the final speed (τ_{final});
- acceleration (a) when gaining the speed from V_o to V_{final};
- the step-down (step-up) vertical separation of the fighter with respect to the target (ΔH).

The initial direction parameters can vary within considerable limits, that makes it possible to select the most optimum flight trajectory for the fighter in each particular direction to the target.

232. In the СРП computer, envisaged are one main, four auxiliary and three special modes of operation. They are as follows:

1. The NORMAL SOLUTION mode, the main one.
2. The Q_{tgt} and V_{tgt} MANUAL SETTING (РУЧНАЯ УСТАНОВКА $Q_{ц}$ и $V_{ц}$) mode, the auxiliary one.
3. The τ_o celest ($\tau_{o\ астр}$) mode, the auxiliary one.
4. The τ_{tgt} celest ($\tau_{ц.астр}$) mode, the auxiliary one.
5. The τ_{tgt} const ($\tau_{ц.пост}$) mode, the auxiliary one.
6. The PREPARATION mode, the special one.
7. The RETURN (ПРИВОД) mode, the special one.
8. The TRAINING (ТРЕНАЖ) mode, the special one.

The main and auxiliary modes are designed for direction proper, while the special ones, for solving the different tasks before and after direction.

Mainly the modes differ one from another in nature of computation of the interception line with reference to which the fighter flight trajectory is plotted for solving the direction task by different methods.

233. During preparation for direction, proceed as follows:

- set the targets markers to the air target potential detection line, and the fighters markers, to the initial direction point;
- set the selected target course and speed;

- select the PREPARATION mode for the СРП computer and the required value of $\Delta\tau$;

- set the direction mode and parameters depending on the target characteristics;

- set the fighter course equal to that for entering the direction initial point (do not apply a correction for variation to the СРП computer);

- keep a running check of the air situation, especially of the area where an air target is awaited.

234. As the air target appears, estimate its moving parameters (course, speed, altitude) and supply the operator of the target data removing device with the target designation for tracking the target.

Give the pilot a command to start the engines and inform him on the flight regime, wave number, separation and code.

Start the seconds counter to clock the passive time and subsequently reduce its value on the СРП computer every minute.

Set the direction parameters with reference to the verified target flight speed and altitude.

As the seconds counter reads the time equal to the passive one, the fighter should be at the initial direction point. Upon approaching the initial direction point, reset the passive time and cancel the PREPARATION mode. As the fighter marker appears on the УД display, give the fighter data removing device operator the target designation and align the pointers of the transmitted course with the indicated one to mesh them. Make sure the direction commands are duely transmitted to the fighter systems and give the "Fulfill commands" instruction to the pilot.

If the time for realization of the climb program is insufficient, proceed as follows:

- transmit the "Reheat" command to the pilot;

- select the $\tau_{o\ celest}$ mode and set its value equal to the acceleration climb time with the engines running at reheat power;

- disengage the flywheel of the transmitted course, vary the direction parameters to obtain the stable solution of the direction task and align the pointers of the transmitted course with the indicated one:

If it is impossible to solve the direction task by the said method, proceed as follows:

- select the $\tau_{tgt\ celest}$ mode and set the target flight time equal to that of the climb program realization and performance of the maneuver for the target attack;

- determine the plotted track of the fighter against the CPП computer scale and by varying the direction parameters, select a course for the fighter to be directed to the target in compliance with the target assigned flight time.

235. When the fighter is directed from the air alert zone, the task is solved in a similar way but without regard for the passive time. The fighter acceleration altitude is selected depending on its flight altitude in the zone.

When the fighter is in the air alert zone, the fighter data removing device operator should track the fighter or set the fighter marker to the centre of the alert zone.

In the process of the entire instrument direction, check the following:

- accuracy of tracking of the target and the fighter by the УСД data removing device operators and indication of the target moving parameters;
- the target flight altitude and fighter climb;
- passing of commands over the automatic radio-link equipment and their execution by the pilot;
- the position of the destruction line marker.

On the flight leg when flying at the initial speed, check the following:

- the fighter acceleration altitude climb;
- passing of the "Straight", "Turn" commands and turning with reference to ρ, if the turn is performed on that leg;
- variation of τ_o, execution of the "Reheat" command at remaining τ_o = 10 to 25 s and execution of the command by the pilot (duplicate the "Reheat" command over the radio);
- start of follow-up of the fighter flight variable speed at $\tau_o = 0$.

236. If the fighter approaches the acceleration altitude earlier than time $\tau_o = 0$ is followed up, set $\tau_o = 0$ by increasing τ_{final} in the NORMAL SOLUTION mode or by pressure toggle switch τ in the $\tau_{o\ celest}$ mode to cut in the fighter variable speed circuit. If the fighter approaches the acceleration altitude later than time $\tau_o = 0$ is indicated, select the PREPARATION mode to cut out the fighter flight variable speed circuit. As the fighter intercepts the acceleration altitude, cancel the PREPARATION mode.

237. On the fighter acceleration leg, the combat control officer should proceed as follows:

- determine correspondence of estimated τ_{final} to the required one against the flight time left after subtraction of the acceleration time;

- by the pilot's report, check correspondence of the speed attained by the fighter to that indicated on the instrument (if the speed difference is more than 100 km/h, use the V_0 pressure toggle switch to set the speed gained by the fighter on the CPП computer);

- check execution of the turn and the fighter leading range after the turn.

238. On the flight leg while flying at the final speed, check the following:

- correct change to the third stage and stable decrease of the flight time and follow-up of the fighter flight course;

- passing of the range commands (100, 60, 36) and the airborne radar illumination cut-in (duplicate the command on cut-in of the radar illumination over the radio);

- set the V_{final} - V_{clos} toggle switch to the V_{clos} position to transmit the closure speed to the fighter systems.

239. When the fighter is directed to the maneuvering target, use the auxiliary $\tau_{tgt\ const}$ and Q_{tgt} and V_{tgt} MANUAL SETTING modes which allow the pilot to stabilize the process of approaching the target area.

When the direction task is solved in the $\tau_{tgt\ const}$ mode, proceed as follows:

- upon detection of the target maneuver, disengage the flywheel of the transmitted course and select the fighter flight course to the target area;

- set the aspect angle (Θ) equal to 0 or 180°;

- use pressure toggle switch τ to set the target flight time of 30 to 50 s;

- upon computation of the indicated speed on the CPП computer, align the pointers of the transmitted and indicated courses and engage them;

- in the process of direction, check the altitude climb, determine the "Reheat" command application moment with reference to the distance flown before turn initiation and time of turn versus the angle of turn and closure speed;

- in the process of turn, when the fighter position with respect to the target ensures detection and aiming, change over to the "interception" or "pursuit" method.

If a general flight direction of the target can be determined, manually set the course and speed of the target. In this case, proceed as follows:

- turn the flywheels of the target course and speed to set the mean values of the target course and speed (do not depress the flywheels);
- check the follow-up of the target course, flight speed and altitude (by the УСП target data removing device operator);
- if the difference between the set and indicated values of the course and speed is considerable, smoothly align their indexes;
- if it is necessary, change the fighter preset final speed and the direction parameters in compliance with the new target speed;
- upon computation of the fighter new indicated course by the СРП computer, smoothly align the indexes;
- check the fighter climb, generation of the "Reheat" command and initiation of the variable speed computation;
- attentively watch the position of the fighter with respect to target and, if required, visually bring the fighter into the target rear or front hemisphere.

240. When the fighter intercepts the target closure straight leg, solution of the direction task is continued by the "interception" method. To gain the required closure speed when attacking the target, it is expedient to select the reheat power for the fighter engines. After execution of the attack and upon bringing the fighter to a safe side, give the pilot a command to disengage the reheat (if it has been engaged), request the fuel remainder and bring the fighter to the landing airfield.

241. To solve the task on homing the fighter to the landing airfield, use the special RETURN operating mode of the СРП computer of the instrument direction equipment.

The said mode is turned on by the RETURN (ПРИВОД) toggle switch and it is used together with the target course and speed manual setting mode. When the mode is selected, the target flight time is no more computed on the СРП computer and the readings of "τ" will be valid only for the fighter flight time. The fighter flight path is computed with respect to the target marker coordinates with regard for set direction parameters $Q_{tgt\ set}$, R_o, ℓ_o, Θ_o. Other parameters are of no importance.

The fighter is lead to the landing airfield by two methods, namely:

- "maneuver" (the fighter is lead to the landing airfield from the estimated line);
- "pursuit" (for circling approach).

In the RETURN mode, the following commands are transmitted to the fighter systems:

- the fighter course (Q_{ftr});
- the fighter flight speed (V_{final});
- the target altitude (H_{tgt});
- the range discrete commands.

When the fighter is brought to the landing airfield by the "maneuver" method, the combat control officer should set the following parameters on the CPП computer:

- $Q_{tgt\ set}$, equal to the runway landing heading;
- R_o, with regard for the speed and roll of the fighter during its turn to the runway landing heading;
- ℓ_o, equal to the distance to the airfield after the turn;
- θ_o, equal to zero.

Give the target data removing device operator a command to set an altitude, equal to the flight altitude to the descent line (at $\Delta H = 0$), and as the fighter approaches the descent line, the turn altitude to the runway landing heading.

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